The Vortex Electron's Tiny Revolving Point Charge and How it Generates its Magnetic Moment, its Angular Momentum, its Mass, and How it Gives Rise to its de Broglie Waves

Also,

The First Direct Measurements of the PVT Surface and Melting Curve Minimum of Solid Helium-Three

Ernst L. Wall

Institute for Basic Research

Palm Harbor, FL

To see the broad spectrum of the ongoing work at the Institute for Basic Research, visit their web site by clicking here.

This web site was originally created in 1995 by January 6, 2018

Comments welcome. Send them to - e_wall@tachyonmodel.com

Also, see the global warming website by this author, www.gwphysics.com.

Foreword for the Revolving Charge Particle Model

1. Four Major Failures of the Standard Model of the Electron

The Standard Model, which dates back to the 1960s (some 50 years ago), is claimed to be the most successful particle model ever. However:

1. It fails to provide a physical mechanism that generates the electron's magnetic moment.
2. It fails to provide a physical mechanism that gives rise to the electron's angular momentum.
3. It fails to provide a physical mechanism for generating the electron's mass.
4. It fails to provide a physical mechanism for the origin of the electron's de Broglie waves.

The Standard Model views the electron as a tiny ***stationary*** 10^{-18} cm charge with implicit "magical" properties of magnetic moment, angular momentum, and mass, which are relatively large quantities that cannot be supported by such a tiny particle if it is stationary.

2. Using Extreme Simplicity in Order to Succeed Where the Standard Model Fails: The Revolving Charge Vortex Electron Model

We start with a model the Electron that consist of a tiny point charge that revolves at the speed of light in a Compton wavelength orbit and behaves Like a trapped, or bound photon. It provides the physical mechanisms behind the electron's measured parameters. These are:

1. Its magnetic moment in the form of the Bohr magneton. See Section 1.5.
2. Its mass. See Section 1.8.
3. Its angular momentum. See Section 1.9.
4. Its de Broglie waves. See Section 1.11.

(Note that all of the models provided here are based on published material.)

3. The Revolving Point Charge Models of the Proton, the Neutron, and a Yukawa-Like Deuteron

1. The **Proton**: See Section 2.1**.**
2. The **Neutron**: See Section 2.2
3. The **Yukawa deuteron**: See Section 2.3.

4. Pion Resonances and the Meson Equation. See Section 3.0.

5. The Tachyon and the Electron. See Section 4.0.

This provided the original derivation of the revolving charge model of the Bohr magneton. It is shortened to 3 equations in Section 1.

6. The Neutrino. See Section 5.0.

7. The Effect of the Compton Wavelets on the First Bohr Radius of the Hydrogen Atom. See Section 6.0.

8. Unresolved Issues With the Above Particle Models. See Section 11.0.

The specific journal articles are listed below each derivation as well as a chronological list in Section 21.

Additional Content Beyond Particle Physics

(Click on the links below in order to jump to the content)

1. Section 17 describes the first direct measurements of the PVT surface of solid helium-three and its melting curve minimum.
2. Section 18. Nuclear physics equipment at the University of GA in the late 1950s.
3. Section 19. Design techniques for large bore, split pair superconducting magnets.
4. Section 20. The Savannah Symphony
   - Surprisingly, there are a few worthwhile things in life besides physics.
5. Section 21. Publications by Ernst Wall

Appendices:

Appendix 1. The Electron and the Fine Structure Constant, the Dirac Model, and Other Aspects of the Electron in the Hydrogen Atom.
- This appendix contains additional commentary on the relationship between this model and the Dirac model, the Zitterbewgung frequency, and other quantum mechanical issues, as well as some new aspects of the fine structure constant.
- Section A1.11 contains a vortex electron-through-the-double-slit experiment

Appendix 2. Time Travel, tachyon theories notwithstanding, is totally impractical

Appendix 3. What Happens if you Dare to Ask a Quantum Mechanic, " What Waves When You Have de Broglie Waves ?"

Appendix 6. My Helium-3 Transducer/Strain Gauge Made it to the Smithsonian

---

1.0. The Revolving Point Charge Model of the Vortex Electron: A Very Simple Model of the Electron

1.1. First, a definition: The Compton Wavelength

The Compton wavelength will be central to our development of the electron model as well as for the first Bohr radius in a Section 6. It will be the circumference of the electron, and it may be expressed as[1] (See footnotes at end of Section 1.)

$$\lambda_C = \frac{h}{mc} = 2.4263102389\text{E-}10 \text{ cm.}$$

This expression was derived by Arthur Compton in 1923 during his investigations of electron-photon scattering, and this wavelength has an energy equal to that of the rest mass of an electron.

Also, we will need the **reduced Compton wavelength** for the electron radius, which is given by

$$r_e = \frac{\lambda_C}{2\pi} = \frac{\hbar}{mc} = 3.861592678\text{E-}11 \text{ cm .}$$

1.2. The Size of the Electron's Charge: It is Very Tiny, About 10^{-18} cm, or Less, in Diameter

High energy scattering experiments indicate the electron's charged particle has a diameter of some 10^{-18} cm, or less, some 243 million times smaller than the Compton wavelength. (See cross section graph in Appendix 5.)

Note that this tiny charge radius is not the classical charge radius. It is much, much smaller than even the classical charge radius. The classical charge radius is discussed in Section 6.

1.3. The Revolving Charge Particle Model

In this model, the electron's charge revolves in a Compton wavelength orbit at exactly speed of light as if it were a bound, or trapped photon [1, 10, 25]

The electron's radiation mechanism and its converse of why the internal revolving charge does not radiate its energy away in a cyclotron fashion is covered in Sections 1.8, 1.11 and 1.12.

See Section 4 for the mechanism that keeps the charge revolving in an orbit.

1.4 Magnetic Moment: A Definition

The magnetic moment of a magnet is the quantity that determines the torque that the magnetic will experience when it is placed in an external magnetic field.

The magnetic moment of a current loop is determined by multiplying the area of a loop by the current through that loop. I.e., it is given by

$$\boldsymbol{\mu = IA},$$

where I is the current and A is the area of the loop.

In the case of the electron, the revolving charge creates a current around the periphery of the electron's area, and this gives rise to the magnetic moment of the electron.

1.5. A Derivation of the Electron's Magnetic Moment in Three Easy Equations

First, we need to calculate the current created by the electron's revolving charge.

Using the above orbital dimension and velocity of the electrons revolving charge, the charge's frequency of rotation is given by

$$\mathbf{f_e = \frac{c}{\lambda_C} = \frac{mc^2}{h} = 1.23558996\ E\ 20\ Hz}\ . \qquad (1\text{-}1)$$

Next, if an observer were standing near the circular orbit of the revolving particle, the current that he would see passing him would be given by the number of charges per second passing by him, or

$$\mathbf{I = nq = f_e q = \frac{c}{\lambda_C}\frac{e}{c} = \frac{e}{\lambda_C}}, \qquad (1\text{-}2)$$

where we use the orbital frequency from Eq. 1-1, above, and the cgs units of charge, q = e/c.

Having obtained the current generated by the revolving charge, we now multiply the current by area.

I.e., the magnetic moment of an orbiting charge, μ, would be the product of the current passing a point on the orbit multiplied by the area of that orbit. I.e., we would have

$$\mathbf{\mu = AI = \left(\pi r_e^{\,2}\right)\left(\frac{e}{\lambda_C}\right) = \frac{e\,\lambda_C}{4\pi} = \frac{eh}{4\pi mc} = \frac{e\hbar}{2mc} = \frac{e r_e}{2}}\ \textbf{ergs/Gauss}. \qquad (1\text{-}3)$$

Here, the 10^{-18} cm charged particle revolves at the speed of light in an orbit whose radius is the reduced Compton wavelength as defined in Section 3.1, above. I.e., the charge size is some 243 million times smaller than the orbital radius.

That is, we have derived the Bohr magneton, which is defined as

$$\boldsymbol{\mu = \frac{e\hbar}{2mc}}\ ,$$

and which is the known magnetic moment of the electron. Furthermore, we have done so using only 3 easy equations.

To understand what maintains the revolving charge in a circular orbit, see Section 4.

The reason the charge is able move at the speed of light is that it has no mass in and of itself. As will be shown, the electron's mass is contained in the electromagnetic field within its orbital disk, and not in the charge.

For original publications where the above was originally derived, see:

1. Ernst L. Wall. "The Role of Tachyons in Electron Spin and Muon Spin", Bulletin of the American Physical Society **30**, p. 729 (1985). [26}
2. Ernst L. Wall. "Indirect Evidence for the Existence of Tachyons; A Unified Approach to the Pion ® Muon ® Electron Conversion Problem", Hadronic Journal **8**, p. 311 (1985). [25]
3. Ernst L. Wall. Book, **The Physics of Tachyons**, 234 pp., (Hadronic Press, 1995)
4. Ernst L. Wall, "The Tachyonic Electron's Revolving Light Speed Particle as a Non-Radiating, Bound Photon", Hadronic Journal Supplement **15**, p. 419 (2000). [10]

Also, see Section 4, which is the derivation of the Bohr magneton as derived from a tachyon based model. Everything on this page had its origin in that one derivation.

We should note at this point that this magnetic moment is in error with experiment by about 1 ppt. More will be said about this in Section A1.6, below.

We note, however, that a more rigorous approach needs to be carried out on the above.

It must also be noted that the above is not an ad hoc model of the electron. It came as a result of modeling the electron by utilizing a muon and a negative mass tachyon. The binding energies used were the cutoff energy of the μ → e decay curve. That derivation is relatively long (27 equations), and is provided in Section 7, below

-

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

1.6. The Original Bohr Magneton Derivation by Means of a Negative Mass Tachyon Model

It may appear that the above is an ad hoc derivation. However, it is not. It had its origin in a negative mass tachyon model where the tachyon's binding energy was half the cutoff energy of the μ → e decay curve.

That led to the derivation of the Bohr magneton which is shown in Section 4.

Everything else on this page is derived from the revolving charge that arose from that model.

Note also that the imaginary mass tachyon was abandoned as worthless because in the 60+ years since it was proposed, it has produced nothing that agreed with experiment. It was, in fact, derived from flawed logic in that hyperluminal phenomena was extrapolated to superluminal phenomena.

However, Bilaniuk, Deshpande, and Sudarshan deserve an honored place in the history of physics for getting a conversation started on the possibility of hyperluminal particles.

1.7. The Electron's Trapped Photon Hypothesis:

The electron's revolving charge behaves as if it is a bound, or trapped photon that has the wavelength of a Compton wavelength.

1.8. A Utilization of the Electron's Trapped Photon Hypothesis: A Derivation of the Mass Energy of the Electron in Two Easy Equations.

If we continue with the revolving charge model, we may calculate the electrons mass-energy by treating this revolving point charge structure as if it has no mass in and of itself. Instead, we view the charge it as if it were a trapped photon [1, 10, 25]. We then apply the Einstein photoelectric relation to the Compton frequency, we have for the energy of the electron's charged particle,

$$\mathbf{E = hf_e = h\frac{c}{\lambda_C} = h\frac{mc^2}{h} = mc^2} \quad , \qquad (1\text{-}4)$$

which is a triviality.

Hence, the mass-energy of the electron appears to be trapped in its internal electromagnetic field, not in the charge itself. As a result, the charge is not precluded from moving at the speed of light. As will be shown later with the angular momentum model, it is likely that the electron's mass energy is spread uniformly within its circumference.

But to take the derivation a step further, we make the obvious observation that if we simply multiply the Compton wavelength, λ_C, in Eq. 1-4 by the Lorenz-Fitzgerald contraction, then instead of Eq. 1-3 we have that

$$\boldsymbol{E = \frac{mc^2}{\sqrt{1-\left(\frac{v}{c}\right)^2}}}. \qquad (1\text{-}5)$$

That is, we treat it as if the Lorenz-Fitzgerald contraction for a closed particle structure affects both the dimension transverse to the dimension longitudinal to the velocity dimension as well as the longitudinal dimension itself. It is to be noted that if the transverse and longitudinal dimensions were different, it would mean the charge would oscillate in and out with respect to the center of the electron. What the implications of this are is unclear at this time.

However, we note overall that this is more of an observation than a real derivation or a rigid proof. It does, however, hold true under experiment.

Also, Equation 1-4 indicates that the rest mass energy of the electron is electromagnetic energy that is contained within its orbit. Because of this, there is nothing to preclude the charge itself from being created as a light speed artifact.

Hence, while we claim that we have derived the rest mass energy of the electron based on the Compton wavelength as the fundamental circumference of a revolving charge, we cannot call it is a rigid proof. Nonetheless, it is the known mass energy of the electron.

Note also that Eq.1-4 is well known to be the energy of a Compton wavelength photon. However, we believe that there has been no prior claim that this equation is explicitly the mass energy of the electron itself due to its consisting of a revolving light speed, point charge. While we cannot prove this, we treat it as such because it is a useful concept to be used until more information is obtained.

We will later show evidence that the charge behaves as if it is a point charge in that it generates a dynamic electric field as opposed to a static field. We do this by deriving the de Broglie waves from this dynamic field.

It should be noted that we have carried out these derivations without using wave mechanics. We will say more about this in Section 3.7 where we discuss the origin of the de Broglie waves which is external to the structure of the electron.

Note that the same methodology used above also holds true for the muon, but not the pion.

For the original publications from which the above was derived, see:

1. Ernst L. Wall. "Unresolved Problems of the Tachyonic Models of the Electron and the Muon", Hadronic Journal **9**, p. 263, (1987). [23]
2. Ernst L. Wall. Book, **The Physics of Tachyons**, 234 pp., (Hadronic Press, 1995)

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

1.9. A Utilization of the Electron's Trapped Photon Hypothesis: The Origin of the Electron's Spin Angular Momentum

The above is a description of the model of the magnetic moment of the electron that was an unexpected result that was derived from a negative mass tachyon. The mass energy equation was an obvious extension of that model.

But an issue that has not been addressed as yet is that of the electron's angular momentum.

To address the issue of the electron's angular momentum, we note that if we view the revolving charged as a trapped photon, and If this photon's mass is contained in the orbital circumference, then the orbital momentum would be [2, 7]

$$\boldsymbol{p} = \frac{\boldsymbol{E}}{\boldsymbol{c}} = \frac{\boldsymbol{m}\,\boldsymbol{c}^2}{\boldsymbol{c}} = \boldsymbol{mc}\,. \qquad (1\text{-}6)$$

The angular momentum would be, of course,

$$\boldsymbol{L} = \boldsymbol{r_C}\,\boldsymbol{p} = \frac{\hbar}{\boldsymbol{mc}}\;\boldsymbol{mc} = \hbar\,, \qquad (1\text{-}7)$$

where $\boldsymbol{r_C} = \boldsymbol{\lambda_C}/2\boldsymbol{\pi}$, and is the reduced Compton wavelength.

However, in the derivation of Eqs. 1-4 and 1-5, we stated that the mass energy was contained in the internal field of the electron, probably more or less uniformly. Because the internal field is directed at the speed of light toward the center of the electron, that will maintain a constant angular momentum. Hence, we make the following hypothesis:

The Electron's Spin Angular Momentum Hypothesis: The mean electron mass over time is *uniformly* distributed across the electron's area with a constant angular velocity. Therefore, its angular momentum will the same as that of a rotating disk, which is to say, it will be half that of Eq. 1-6, or

$$\boldsymbol{L} = \frac{\hbar}{\boldsymbol{2}} = \boldsymbol{S}\,, \qquad (1\text{-}8)$$

which is the known spin angular momentum of the electron. We have derived this in three easy equations [2, 7, 10].

However, we must emphasize that *this is an unproven working hypothesis, and not a rigorous proof.*

But to provide some credence to this hypothesis, we state again the mass energy derivation, above, indicates that the mass energy is distributed over the interior. More importantly, the magnetic field appears to permeate the entire disk of the electron in order to produce the Bohr magneton, indicating that a considerable amount of mass-energy is here. What will not be shown, as yet, is that the mass energy is uniformly distributed over the interior in a disk or relatively thin cylinder.

Clearly a detailed analysis of the distribution of the internal mass energy field of the electron needs to be carried out and further, it will need to be uniform in order to validate Eq. 1-8.

The external field distribution will be discussed in more detail in Section 1.9, below.

It is interesting to note that If we were to calculate the de Broglie wavelength using Eq. 1-6, above, for the orbital momentum, we would have

$$\boldsymbol{\lambda_D} = \frac{\boldsymbol{h}}{\boldsymbol{p}} = \frac{\boldsymbol{h}}{\boldsymbol{mc}} = \boldsymbol{\lambda_C}\,. \qquad (1\text{-}9)$$

I.e., the de Broglie wavelength of the electron's revolving charged particle would be the same as its circumference, namely, the Compton wavelength.

It is to be noted that it is well known that the first Bohr orbit's de Broglie wavelength is equal to the orbit's circumference, just as would be the case here.

However, there is that troublesome little problem of the angular momentum being half of what 1-7 provides.

Moreover, this has little obvious meaning with reference to the de Broglie wavelength as described in Section 1.6.

For the original publications where the angular momentum was originally derived, see:

1. Ernst L. Wall. "The Electron's Angular Momentum", Bulletin of the American Physical Society **58, NEF13-2013_000008**, October, 2013 . [7]
2. Ernst L. Wall. "A Study of the Fundamental Origin of the Dimensions of the Bohr Radius of the Hydrogen Atom as Determined by the Quantized Dynamic Electric Field Surrounding a Vortex Model of the Electron." The Hadronic Journal **39**, p. 71, (2016) [2]
3. Ernst L. Wall, "The Tachyonic Electron's Revolving Light Speed Particle as a Non-Radiating, Bound Photon", Hadronic Journal Supplement **15**, p. 419 (2000). [10]

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

1.10. The Vortex Model of the Electron

An observer standing near charge's circular orbit will experience a bump from the electric field emitted by the passing charge. More specifically, it is a dynamic impulse field that arises from the revolving point charge and spirals outward at the speed of light after the manner shown in Figure 1, below. This spiraling field, first proposed in 1998, is not unlike the spiraling stream of water ejected from a spinning water sprinkler, although "vortex" is a the common term. See the references at the end of Section 1.11, as well as the author's publications, [2, 5, 3, 4, 5, 10, 12].

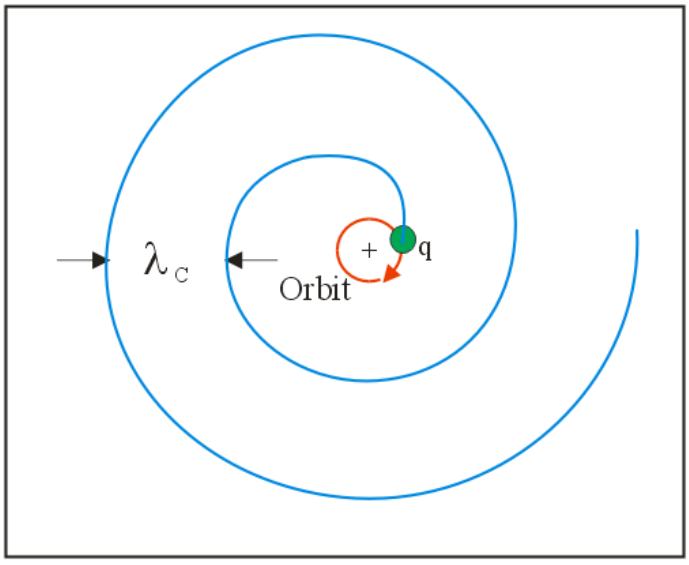


Figure 1-1.

- **The red circle is the charge's orbit and the green dot is the charge, and the cross is the center of the orbit.**
- **The spiraling, dynamic electric field of the revolving electron is shown here in its orbital plane.**
- **Note that the spacing between succeeding wavelets in the spiral is equal to the Compton wavelength for the electron.**
- **This could well be referred to either as a "water sprinkler" model or a "vortex" model.**
- **In addition, we would expect that this is a 3-dimensional effect in that wavelets are also generated vertically along the spin axis. See Section 9.**

The important issue here is not just that the field is a spiraling field, but that the spiraling field forms wavelets that move outward at the speed of light with a spacing that is the same as the orbital circumference, λ_C, which is equal to the Compton wavelength for the electron. Because of this, we refer to them as *Compton wavelets,* or as, simply, wavelets. This also implies that the spiraling field or an electron fills all space out to infinity. Otherwise, the electrostatic extent of the electron's field would be limited.

1.11. The Origin the Electron's de Broglie Waves in Three Easy Equations

As a convenient starting point, consider the interactions between the wavelets of two electrons, A and B, that are shown in Figure 1-2, below. If the electrons are stationary, then the wavelets from the two electrons will move outward at the velocity of light with a constant phase relationship with one another. But if B is stationary and A moves slowly with velocity v past particle B, then a nearby observer will see the relative phase of subsequent wavelets change, going in and out of phase. In one unit of time t, the electron will move a distance d, and the relative phases of the wavelets will change continuously.

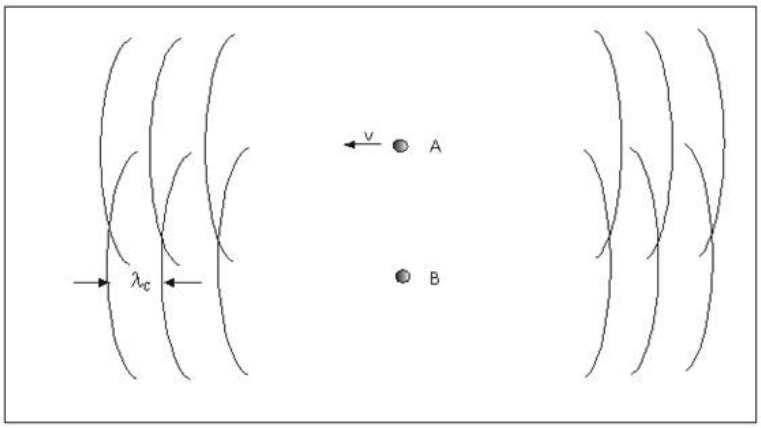


Figure 1-2. The phase interactions of the de Broglie waves of two electrons.

When the relative phase is 0 (or 2p), then a double wavelet will occur. (This model will not work otherwise. It is at this point that the electron's charge is nearly perpendicular to the wavelet it is bumping into.) The number of these doublets, or phase crossings, that will occur in that time unit is

$$\mathbf{n} = \frac{\mathbf{d}}{\boldsymbol{\lambda}_c} = \frac{\mathbf{v\,t}}{\boldsymbol{\lambda}_c} = \frac{\mathbf{m\,c\,v\,t}}{\mathbf{h}}. \qquad (1\text{-}10)$$

Using the definition of the Compton wavelength, $\boldsymbol{\lambda}_c = \frac{\mathbf{h}}{\mathbf{m\,c}}$ we have that the frequency of crossing, which we define as $\mathbf{f_D}$, is

$$\mathbf{f_D} = \frac{\mathbf{n}}{\mathbf{t}} = \frac{\mathbf{m\,c\,v}}{\mathbf{h}}. \qquad (1\text{-}11)$$

Because the wavelets are light speed entities, we may solve Eq. 1-10 for a wavelength between the crossings as

$$\boldsymbol{\lambda_D} = \frac{\mathbf{c}}{\mathbf{f_D}} = \boldsymbol{c}\,\frac{\boldsymbol{h}}{\boldsymbol{m\,c\,v}} = \frac{\boldsymbol{h}}{\boldsymbol{m\,v}} = \frac{\boldsymbol{h}}{\boldsymbol{p}}, \qquad (1\text{-}12)$$

Thus we have that the spacing of the phase crossings (the doublets) of the wavelet are propagated outward with spacings between them of $\boldsymbol{\lambda_D}$, or, in short,

$$\boldsymbol{\lambda_D} = \frac{\mathbf{h}}{\mathbf{p}},$$

which is obviously the de Broglie wavelength by definition. We have obtained this in 3 easy equations.

Obviously, the wavelets do not simultaneously move in and out of phase in the entire pulse train as the charge moves. Only those wavelets that are emitted after a given incremental movement will have a new phase relationship, so that an observer at some distance away in the direction of v would see the passing wavelets moving at the speed of light and going in and out of phase at the frequency f and with a resultant spacing between phase crossings of λ_D.

But what we described above is a simple mathematical construct. The physical significance of the crossing of these wavelets is that they are correlated with the revolving charge, so that it is not, in fact, the crossing of the wavelets from the two electrons that is important. It is the coincidental head-on, perpendicular collision of a wavelet from one electron with the revolving charge of the other electron that imparts an impulse to the charge that encountering the wavelet. I.e., this occurs when the electron's charge collides with a wavelet when its charge's radius vector is perpendicular with the wavelet.

What we cannot say is how much energy is contained within the wavelets that extend out to infinity. We speculate that perhaps the static energy in the charge has the same magnitude as that contained in the dynamic electromagnetic field of the electron. However, without a dynamic electromagnetic component, it might not interact with gravity nor provide inertia. We must also as what is then energy contained in the wavelets, and or what happens to the energy in them when the electron is suddenly moved by an impulse. Clearly they do not interact with gravity nor take part in inertia.

Note also that these Compton wavelets are used to determine the first Bohr radius to an accuracy of 52 ppm in Section 8.

Finally, this model also applies to the proton and the neutron, although the dimensions of the wavelets will be determined by the radii of those particles.

In any case, we still have much to learn.

For the original publications from which the above was derived, see:

1. Ernst L. Wall, "The Fundamental Electrodynamic Origin of Electron de Broglie Waves", Hadronic Journal Supplement **15**, p. 123 (2000).
2. Ernst L. Wall, "Revisiting the Bohr Atom 100 Years Later", Bulletin of the American Physical Society, **N32.00002**, **58**, 2013.
3. Ernst L. Wall, "A Possible Origin of the Fine Structure Constant", Bulletin of the American Physical Society, **59,** New England Section Fall Meeting, **E2.0005**, 2014.

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

1.12. Wave Mechanics vs Simple Algebra for Particle Calculations

We should comment here that the de Broglie waves are external to the electron. Hence, while the use of wave mechanics to describe the behavior of electrons in an atom is mandatory and is consistent with this model, based on this model of the electron, wave mechanics does not appear to be necessary to describe the internal behavior of the electron.

Hence, we have:

1. **The Particle Physics Wave Rule: Using wave mechanics inside particles cause monumental obfuscation of what is an otherwise simple problem. Only classical mechanics should be used inside particles.**
2. **Wave mechanics must be used externally to the particle to describe its fields and its interactions with other particles.**

We will also discuss this more detail in the interaction of the Compton wavelets with the hydrogen nucleus in Section 8 where we will discuss the first Bohr radius.

1.13. Why an Accelerated Vortex Electron Radiates

An accelerated electron radiates, quite simply, because the wavelets in front of it are compress and those behind it are decompressed. This causes an increasing potential difference between the front and back, and the increasing potential difference across the finite extent of the electron causes an increasing electric field that, in turn, that generates radiation, or photons. See Figure 1-3, below.

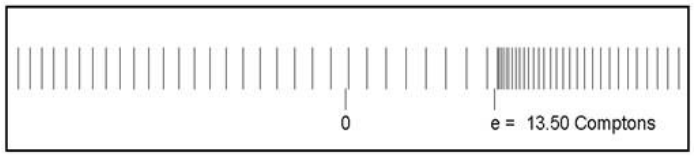


Figure 1-3. The Compton wavelets along the path of an electron that is being accelerating rapidly and linearly towards the right from a velocity of zero up to 0.9c in 30 rotations, where c is the speed of light. It starts from where the electron center is at point 0 up to the point e = 13.50 Comptons, where e is the center of the electron an instant of time before emission in the direction of travel. The accelerations shown here are extreme, and the wavelet counts were chosen for illustrative purposes.

It is also to be noted, as an aside, that it is a resulting longitudinal electric field in that it is moving in the direction of its electric field vector. Nonetheless, it is a changing electric field, so it would be expected to radiate. We make no further comment on this phenomena at this time.

We also note that, as the electron approaches relativistic velocities, its radius contracts, causing its frequency to increase and its Compton wavelets to become even more compressed. We do not show that in Figure 1-3 however.

For convenience in this particular case, we limit this model to the case where the motion is parallel to the electron's plane of rotation. This does not exclude other possibilities, however. (See the case of 2D emission around the circumference of the orbit in Appendix C.)

We note that further analytical work needs to be done here, as well as simulations. That would be with acceleration both along the plane of rotation as well as along the electron's axis of rotation.

For the original publications from which the above was derived, see:

1. Ernst L. Wall. "A Study of the Fundamental Origin of the Dimensions of the Bohr Radius of the Hydrogen Atom as Determined by the Quantized Dynamic Electric Field Surrounding a Vortex Model of the Electron." The Hadronic Journal **39**, p. 71, (2016)
2. Ernst L. Wall, "Revisiting the Bohr Atom 100 Years Later", Bulletin of the American Physical Society, **N32.00002**, **58** (2013)
3. Ernst L. Wall, "A Possible Origin of the Fine Structure Constant", Bulletin of the American Physical Society, **59,** New England Section Fall Meeting, **E2.0005**, 2014.

1.14. Why the Vortex Electron's Internal Revolving Charge Does Not Radiate

Because an electron revolving in a cyclotron emits radiation, it might be expected that the electron's internal charge would radiate as it revolves around the electron's axis because it has a radial acceleration. However, the charge itself is not surrounded by wavelets, so has no means of generating a radial potential difference. Also, because it is too tiny to have a reasonable spatial extent over which to produce a changing field even if there were a potential difference. Hence, it has no mechanism with which to radiate.

Reference:

Ernst Wall, "Why the Vortex Electron's Internal Revolving Charge Does Not Radiate", Bulletin of the American Physical Society, New England Section Fall Meeting, **NEF17-2017-000010,** (2017) – To be published.

1.15. Other Kinds of Electron Vortices

For some other examples of the usage of the term "vortex electron", we note that there is experimental evidence for the existence of what is called a vortex electron, or electron vortex. Uchida and Tonomura have described an experiment that involves the generation of electron beams carrying angular momentum[2] . Also VeerBeck and Schattschneider provide a model describing the production of electron "vortex" beams that consist of spiraling wavefronts[3] . Further, Schattschneider and Verbeeck have proposed a quantum mechanical vortex model where the entire electron carries angular momentum around the center of a beam[4]. However, they utilize dimensions of the order of a micron, whereas we speak of dimensions of the order or the reduced Compton wavelength, or 3.8615926800E-11 cm. These are typically generated by utilizing laser beams to create the angular momentum.

But having pointed out this work, we wish only to state that what we have developed here is a totally different concept that describes the electron itself as generating a vortex around its center, whereas the above phenomena involves the entire electron revolving in a relatively large orbit around the axis of an electron beam.

To distinguish between the Compton wavelength vortices around the electron itself and vortices of electrons in beams, we will simply call the model described here as a "vortex electron of the first kind, or type 1 vortex electron", and those in a beam as "vortex electrons of the second kind, or type 2 vortex electrons".

What effect the present model has on these beams, if any, is unclear at this time, and it is beyond the scope of this work to discuss it further.

NOTE that there is more discussion of the electron in Appendix 1. This covers its relationship to quantum mechanics, the single slit experiment, the Dirac Equation and the Dirac Zitterbewung frequency.

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

©☐Ernst L Wall 2007, All Rights Reserved

Footnotes for Section 1, above.

1. J. Beringer, et al. (Particle Data Group), Phys. Rev. **D 86, 010001**, p. 107 (2012).
2. M. Uchida & A. Tonomura. "Generation of electron beams carrying orbital angular momentum", Nature **464**, pp. 737 – 9, (2010).
3. J. Verbeeck & P. Schattschneider. "Production and application of electron vortex beams.", Nature **467**, pp.301-4 (2010).
4. P. Schattschneider and J. Verbeeck. "Theory of free electron vortices", Ultramicroscopy **111**, pp. 1461-1468 (2011).
5. A. Messiah, **Quantum Mechanics**, p. 951. (1966).
6. Ernst Wall, Bull. Of Am. Phys. Soc (2016), to be published.
7. Eugen Merzbacher, **Quantum Mechanics**, p. 275, John Wiley & Sons, 1961.
8. Leonard I. Schiff, **Quantum Mechanics**, p. 206, McGraw-Hill (1968)
9. Leonard I Schiff, op cit, pp 478, 479.

Terminology: vortex electron, vortex electron theory, vortex electron physics, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, vortex muon, meson, vortex proton, vortex neutron, vortex deuteron, solid helium-three pvt surface & melting curve minimum.

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

2.0. The Revolving Charge Proton and Neutron as Components of a Yukawa-Like Deuteron:

2.1. The Revolving Charge Proton Model

The revolving charge proton model is trivial. It has no hard decay mode as does the $\mu \rightarrow e$ conversion. Hence, we simply model it by using its magnetic moment to obtain its diameter and, for convenience we treat its revolving point charge like that of the electron model.

But in spite of being trivial, it is a first step to the deuteron model and the meson model to be discussed below. There, we treat revolving charge model as if it were a spinning charge ring in the Yukawa-like deuteron model.

Extending the electron model to the proton, the proton's charge, behaves like a trapped photo, as does the charge of the electron, and it revolves at the speed of light in an orbit having a radius of

$$\mathbf{r_p = 0.58736077\ fm.} \qquad (2-1)$$

This produces a known magnetic moment of

$$\mathbf{\mu_p = 1.4106076 \times 10^{-23}\ ergs/gauss.} \qquad (2-2)$$

The nearest analog to the $\mu \rightarrow e$ conversion for the proton is the $\Sigma \rightarrow p$ curve. However, that curve has no clearly defined cutoff energy such as there is for the electron and the muon. Therefore, an inverse approach must be used for the proton. That is, using the electron configuration but the magnetic moment of the proton, $\mu_p = 1.4106076 \times 10^{-23}$ ergs/gauss, we find that the charged particle's orbital radius, r_C, is 0.58736077 fm.

See Figure 2.1, below, the composite proton/neutron diagram.

Note that we do not consider quarks in this model. Nor, do we make any attempt at this time to account for the high energy resonances encountered in pion-proton scattering experiments. We do discuss, however, the mass of the proton and other phenomena as calculated using the trapped photon methodology in Section 4.

It is beyond the scope of our efforts here to pursue this any further at this particular time.

Note that, while it is not explicitly shown here, the proton will be surrounded by wavelets the same as the electron is. I.e., it will be a vortex proton in a manner like the electron.

The proton radius, as determined by scattering experiments, is 0.8768 fm, is about 49% greater than the diameter we calculate here. However, we claim that the radius as determined by a standalone proton parameter, namely, its magnetic moment, is the more accurate radius. The standard radius, being determined by scattering, involves interactions with other particles. If the scattering entity is an electron, it is generally considered to be a tiny 1E-18 cm particle. However, as we showed in section 1, it is much larger, by far, than the proton prior to colliding with the proton. Hence, the value obtained by electron scattering is questionable from the standpoint of this model.

The meson model and the deuteron model, which are based on the above proton radius, provide reasonable agreement with experiment, thus providing further evidence that the radius as calculated from the magnetic moment is the more accurate radius.

The masses of the proton and sigma hyperon are 938.27231 MeV and 1189.37 MeV, respectively. The result is that their mass ratio is R_P =1.2676, and the mass of the tachyon is -251.10 MeV. Using these values in the tachyon model, we find that the radius of the tachyon's orbit is 2.782 fm. (More will be said about calculating the tachyon radius later.) High energy and low energy scattering experiments indicate that these two radii agree with experiment to within 3 %.

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

©☐Ernst L Wall 2007, All Rights Reserved

2.2. The Revolving Charge Neutron Model: A Revolving Charge Proton and Pion Using Two Easy Equations

Like the proton, the neutron is trivial in that we add a revolving pion to the proton and treat it, too, like a revolving point charge (or a ring charge) even thought the pion is normally considered to be a spin 0 particle. The magnetic moment of the neutron and proton are used to derive its magnetic moment.

While trivial like the proton model, when combined with the proton model it produces the Yukawa-like deuteron model discussed below. Also, its pion's energy levels provide the meson model discussed below.

(To go directly to the deuteron model, click here.)

A proton can capture a negative pion and create a neutron via the reaction

$$\pi + p \rightarrow \gamma + n + Q_n ,$$

where the gamma ray, γ, has an energy of 129 MeV and the neutron's kinetic energy, Q_n, is 8.8 MeV, giving a total emitted energy of 137.8 MeV. Note that the 137.8 MeV is rather close to the 139.57018 MeV mass of the negative pion.

Instead of a gamma ray, a neutral pion can be emitted, but we choose not to show that reaction as it is superfluous for our purposes here.

Hence, to model a neutron using the previous proton model, we add a coaxially revolving, negatively charged pion to the center of the positively charged proton. This pion revolves in an orbit having a radius of

$$\mathbf{r_\pi = 0.18503077\ fm}. \qquad (2-3)$$

While quantum mechanical considerations indicate that the pion is a spin 0 particle (zero magnetic moment) we treat it here as if it has a tiny magnetic moment that is too small to interact with other particles except as below.

$$\mu_\pi = 0.4443705 \times 10^{-23}\ \text{ergs/gauss}. \qquad (2-4)$$

It is from this that we derived the above meson equation.

We arrived at this by subtracting the magnetic moment of the neutron (μ_N = 9.6623707 x 10^{-24} ergs/gauss) from that of the proton. From this, we found that the orbiting pion's magnetic moment is μ_π = 0.4443705 x 10^{-23} ergs/gauss. (Note, incidentally, that this value is within 2.5 % of the magnetic moment of the deuteron. More will be said about that shortly.)

Using this value of the magnetic moment to calculate the radius of the orbiting pion's charged particle, we find it to be 0.18503077 fm.

Because the pion is revolving in a manner like that of the electron, it will be surrounded by wavelets as is the electron. I.e., it will be a vortex pion.

For the pion, we will discuss its resonances in the meson model of Section 3.

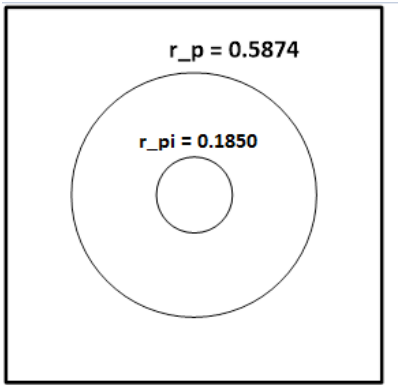


Figure 2-1.

- **This neutron is a composite of the positively charged proton and the negatively charged pion.**
  - **It shows the orbit of the proton's revolving charge and the smaller orbit of the pion's revolving charge**
    - **(Yes, the pion is considered to be spin 0. But to quote Galileo's comments on the Earth after the inquisition, "Nevertheless, it still revolves!").**
  - **The radii are in fm.**
- **The drawing is to scale.**

Some outstanding issues with the neutron model that need resolution:
If we use one of Kellog's ring models to predict the electrostatic energy binding the pion inside the proton, we only get 2.550 MeV, a value which is close to that of the deuteron. That value is just a wee tad smaller than the 137.8 MeV observed conversion energy of the neutron from the proton and pion. Hence, there is an issue to be resolved.

Note, however, that there is no issue with the deuteron, as is shown in the next section.

Also, the mass difference in the neutron and proton is 1.293332 MeV, somewhat lighter than the sum of the proton and pion masses!

Clearly, some work needs to be done to resolve these issues. In fact, a nice little senior physics thesis could come out of this one.

But in spite of this, the neutron model, just as it now is, is quite adequate to model the deuteron extremely well. It also does an extremely good job of accounting for the meson energies in that the Meson Equation is derived from it.

The bottom line? It is the conversion process that is the issue. We use the static value here, so it does not affect the results below in the deuteron model.

For the original publications from which the above was derived, see:
1. Ernst L. Wall. "The Role of Tachyons in Proton Spin", Bulletin of the American Physical Society **30**, p. 729 (1985),
2. Ernst L. Wall. "On Tachyons and Hadrons", Hadronic Journal **9**, p. 239, 1986.
3. Ernst L. Wall. Book, **The Physics of Tachyons**, 234 pp., (Hadronic Press, 1995)

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

©☐Ernst L Wall 2007, All Rights Reserved

2.3. The Light Nuclei, Including a Novel Implementation of the Yukawa Deuteron

A Semi-Classical Implementation of the Yukawa Deuteron:
Note that we call this a "Yukawa Deuteron". It is, of course, a totally different model from Yukawa's quantum mechanical version. However, we call it a Yukawa deuteron because it uses a pion as means of binding two protons together. Also, within the context of this model, Yukawa's utilization of wave mechanics was quite valid because it was based on wavelets external to the protons and the pion. Had it been dealing with the internals of the proton, that would likely be a different story as was the case with the electron.

This is where the proton and neutron models become interesting because here, we take the novel approach of considering the effects of the internal charged particle's interactions on the binding energy.

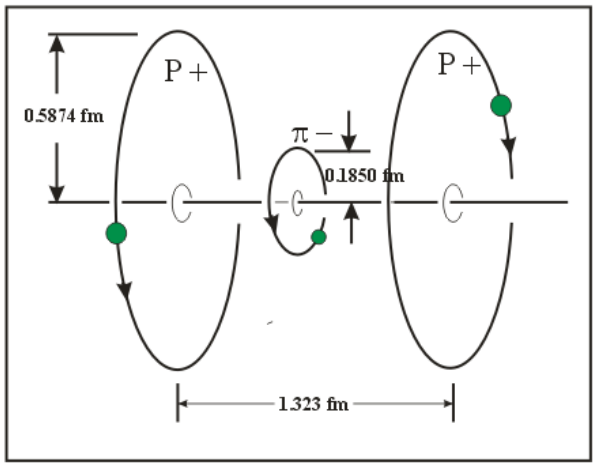


Figure 2-2.

a. **2.444 Mev is the calculated electrostatic binding energy of this Yukawa-like deuteron, which is comparable to the measured energy of its 2.2246 MeV gamma ray, and is more than enough the hold the deuteron together. (The calculation is a somewhat crude approximation and needs to be redone via a computer algorithm, and yes, we know about the nuclear force. A nuclear theorist will not exactly adore this model.)**
b. **This deuteron consists of a proton and a neutron, the neutron being a combination of a proton and a pion, as shown in the prevous drawing. Therefore, we show two positive protons and a negative pion.**
c. **The protons are counter revolving, leaving only the revolving pion to generate a magnetic moment.**
d. **It is a Yukawa-like deuteron in that the pion is an intermediary particle that holds the protons together.**
e. **(While the pion is generally is considered by the Standard Model to be a spin 0 particle with no magnetic moment, it is predicted here that if an accurate, direct measurement is made of its magnet moment, it will be found to be of the order the deuteron's magnetic moment.)**
f. **Note that because this is composed of a two vortex protons and a vortex pion, it will be a composite of three vortices, or it will simply be a vortex deuteron.**

2.3. The Deuteron's Structure and How We Arrived at its Dimensions and Energy:

Note: See comments in 2.6, below, on conventional nuclear models.

1. The radii of the protons provide the radius of the deuteron, 0.5874 fm.
2. The quadrupole moment of the deuteron gives the longitudinal spacing of the positive charges, 1.323 fm.
3. We use the methods outlined in Kellogg's **Foundations of Potential Theory** (Dover Books 1953) to calculate the electrostatic energy of the ring charges, 2.444 MeV, more than enough to hold the deuteron together and within 9.8 % of the energy of the 2.2246 MeV gamma ray that is emitted when the deuteron is formed.
4. It is to be noted that if point particles were used instead of a ring model, but with the same spacing, then the electrostatic binding energy would be 3.27 MeV, more that we have here. The binding energy of the deuteron is less than that because the charge is spread out. That result is because the mutual interaction is spread out over greater distances.
5. The magnetic energy involved the two protons is approximately 0.2276 MeV.
6. The combined magnetostatic and electrostatic energies are 2.6716 MeV, some 25 % greater than the observed binding energy.
7. These calculations assume a continuous electromagnetic field whereas the actual field of the revolving point charges is dynamic, so that a dynamic model would likely affect the energy calculation.
8. Strictly speaking, this is a phenomenological model wherein we observe that the magnetic fields are canceling. A lower energy state, magnetically speaking, would have the rings lined up with their field vectors parallel as opposed to antiparallel if it were a macroscopic charge ring.
9. Both the magnetic fields and the electric fields have a finite propagation time between the point charges within the structure and are likely of the nature of the de Broglie waves for the electron as described below.
10. Note that if we viewed the counter rotating rings as macroscopic current loops, the combined magnetostatic and electrostatic energies are 1.9964 MeV, some 10 % less than the observed binding energy. But again, this is a dynamic particle system with a finite propagation time between particles for both the electric and magnetic fields.
11. Note that these calculations are somewhat crude and need to be redone via computer algorithms. Hence, much work is still needed on this model.
12. We are very cognizant that a suggestion that the nuclear force could possess even a small component of an electromagnetic nature would not go over well in the nuclear theory community.
13. Any reader that wishes to do so is free to model this particle system and verify it. It is very straightforward to carry out. Kellogg's **Foundations of Potential Theory** (Dover Books 1953) is available from Amazon.com.
14. Any reader that considers that this model is incorrect because it does not utilize a nuclear force is welcome to prove that it is wrong.
    a. That is, he must prove it based on experiment and not on disagreement with another model.

We emphasize again that this model should be redone but with a computer simulation of Kellog's algorithms and the magnetic field. That could be an interesting little senior thesis for an undergraduate physics major.

But better yet would be a simulation that uses the dynamic electromagnetic field as described in the de Broglie model of Section 10. That, too, could provide excellent senior thesis material for an undergraduate physics major, or perhaps even a master's thesis.

For the original publications from which the above was derived, see:

1. Ernst L. Wall. "The Role of Tachyons in Proton Spin", Bulletin of the American Physical Society 30, p. 729 (1985),
2. Ernst L. Wall. "On Tachyons and Hadrons", Hadronic Journal 9, p. 239, 1986.
3. Ernst L. Wall. Book, The Physics of Tachyons, 234 pp., (Hadronic Press, 1995)

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

2.4. How the Deuteron's Structure is Held Together

The negatively charged pion inside the neutron is attracted to the nearby protons so that the two positive charges are mutually attracted to the pion. Although the positive charges repel each other, they are at a balance position wherein their mutual repulsion balances their attraction to the pion.

On top of that, their opposite magnetic poles will produce a minor attraction.

In the formation of the deuteron, a proton approaches a neutron and its positive charge attracts the neutron's pion, thus axially deforming the neutron and causing it to behave as a deformable dipole. This would provide an attractive field that would be more exponential than inverse square law as the nuclear force model is known to be. In that case, you might name that force, say, a "nuclear force". But it is, regardless of what you name it, an electrostatic field.

Hence, as the neutron and proton approach one another we have collapsing electric and magnetic fields. Those collapsing electromagnetic fields should produce a photon which is, in fact, what we see. Namely, we see the 2.2246 MeV gamma ray.

But more interesting, while the protons electrostatically repel one other while being attracted to the pion, we have a model that is somewhat similar to the Yukawa model. That is, we have a pion being an intermediary particle that holds the two sigma hyperons together. (We make no claim that it is described by Yukawa's equations, however.)

A better approach to modeling the deuteron than we used originally would be to treat them as revolving point charges and use a computer simulation to calculate the energies. That has not been done as of this time but work has begun on the simulation.

Note also that there is no intent nor even any interest in reconciling this model with the quantum mechanical model. However, it should be noted that this could be a fun project for a physics senior thesis.

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

2.5. The Triton

Similarly, to the deuteron, the crude calculated values for the binding energy of tritium is 28.3 % less than the experimental value, and for the helium-three binding energy is 43 % less than the experimental value. This is discussed in detail in The Physics of Tachyons.

These values are not precise because they are based on crude estimates rather than carefully integrated algorithms. However, in spite of the lack of precision, an argument can be made that these light nuclei could be at least partially bound by electromagnetic forces, and not totally by a separate nuclear force. It is likely that with more careful calculations, better agreement will be obtained.

But if these large errors seem excessive, it should be noted that such errors are not uncommon in the particle physics literature where errors of 50 % or greater are not unheard of.

The calculated magnetic moment of deuterium is within 2.5 % of experiment, the calculated magnetic moment of helium-three is within 1.7 % of experiment, and the magnetic moment of tritium is within 3.5 % of experiment. These are shown graphically in Figure 9.

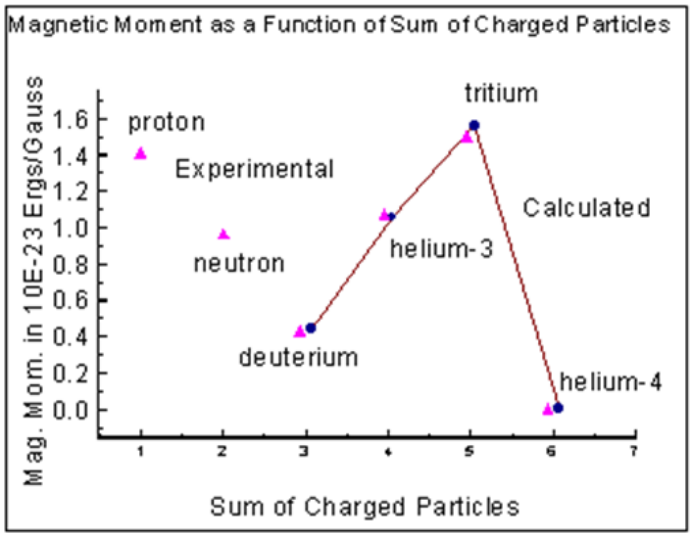


Figure 2-4. The rather trivial chart of measured and calculated magnetic moments of the lighter nuclei that was arrived at by stacking neutrons and protons. The pink triangles are experimental values and the black dots are the calculated values.

Now, about the nuclear force: ……

2.6. The Conventional Nuclear Models.

The conventional structure of the nucleus is discussed in Segre's and Evans' nuclear physics books. It is based on scattering

---

3.0. Pion Resonances: A Totally Unique and Very Basic Single Particle Meson Model

3.1 The Meson Equation

As stated above, we start not with the electron, in which the model originated, but the most spectacular results in the form of the meson model and the deuteron model.

This is for pedagogical reasons.

All meson masses below 4076 in energy can be accounted for by the following Rydberg-like equations. Its excited levels are found to be

$$\mathbf{E} = \frac{\mathbf{4074}}{\mathbf{n^2}} \ \mathbf{MeV.} \qquad (3\text{-}1)$$

with values of the index, n, ranging from 1 through 9. (This expression is similar to the expression for the energy levels of the Bohr model of the atom.)

The derivation of Equation 3-1 is shown below in Section 3.4, and is done in 3 easy equations. The energy levels from Eq. 3-1 and their transition energies are shown in Figure 3-3, below.

However, we show the meson equation here, along with the transition energies in Figures 3.1 and 3.2, before the actual derivation, for pedagogical reasons.

3.2 The Psi Mesons

First of all, we show the theory and experiment for the psi mesons and the light mesons, below.

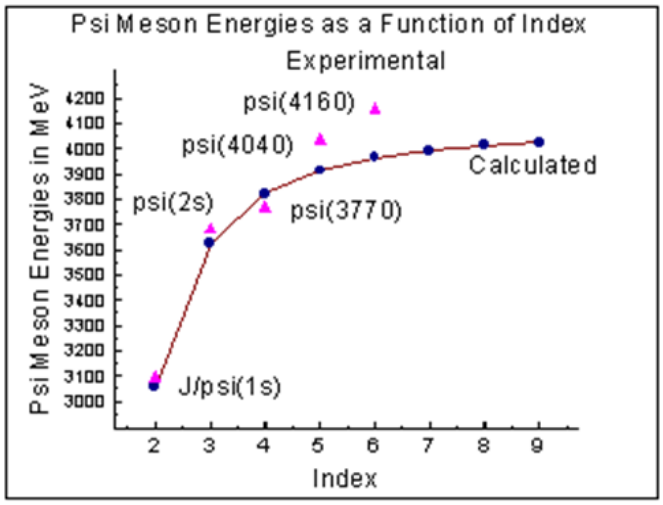


Figure 3-1. The psi mesons, theory and experiment. The black dots are the calculated values, the red triangles are the experimental values.
The error in the calculated values range from -1.3 % to +4.7 %.
Note that we do not need quarks, charm, flavor, strangeness, electroweakness, or any of these unnecessary apparitions.
These mesons are so mundane that they could easily be called the first order Mundanes!
However, on a more serious note, since their atomic analog in the Bohr atom is the Lyman series, perhaps
they should be called "the Lyman mesons" instead of the Psi mesons.

(To see the energy table from which this was derived from, click here.)
The first order transitions, corresponding to the so-called "charmed" psi mesons, are within -1.3 % to +4.7 % of the observed experimental values. (The Bohr Atom's analog is the Lyman series.) These transitions are shown in the transition diagram above, and the values are plotted in the graph above (Figure 10) along with the corresponding experimental values where the index is the value of the energy level, n, that is differenced with the value for n=1.

The first of these resonances to be discovered using p-p collisions was the J particle by S. Ting, and simultaneously the same resonance was found in e-p collisions at the same time by B. Richter who called it a ψ particle. The particle was later named the J/ψ particle, and it has a mass-energy of 3096.9 MeV. The value calculated

using the meson equation, above, is 3056 MeV, which is within 1.3 % of the experimental value.

3.3 The Light Mesons

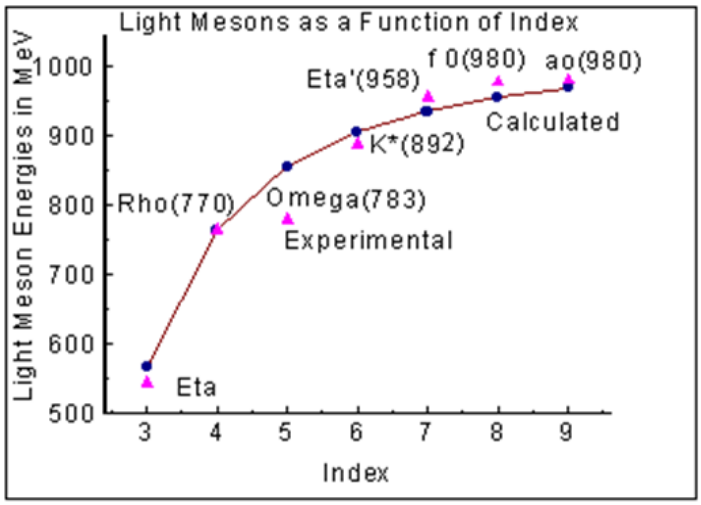


Figure 3-2. The light mesons, theory and experiment. The black dots are the calculated values, the red triangles are the experimental values. The agreement with experiment ranges from 0.5 % to -2.3 %, except for the omega(783), which is within +9.5 % of experiment. These are the second order transitions of the pion energy levels from Figure 2-3, below. Also, we propose to change the name the omega(783) to "Pariahtron(783)" because it seems to be an outcast from the other light mesons. This is possibly indicative of an issue between levels 2 and 5, or some possible energy aberration in the pion structure or energy levels that needs analysis.
These mesons, like the first order mesons, should be called the second order Mundanes, except perhaps, for the "Omega(783)/Pariatron(783)"!
Again, on a more serious note, these resonances are an analog of the Bohr atoms Balmer series, so perhaps they should really be called "the Balmer mesons".

(To see the energy table in a hadron paper from which this was originally derived from, click here.)

The second order transitions (corresponding to the Bohr Atom's Balmer series) produce the seven light mesons, i.e., the h through the ao(980). The agreement with experiment ranges from 0.5 % to -2.3 %, except for the omega(783), which is within +9.5 % of experiment. These are shown in Figure 2-2, above, along with their corresponding experimental values, where the index is the value n that is subtracted from the value n = 2.

(NOTE: The meson graphs shown here (Fig. 1-1 and Fig. 1-2) were put together in the 1990s, so many of the mesons detected since that time have not been added as of yet. They will be reworked as time permits.)

3.4 The Derivation of the Meson Equation

The derivation of meson model is actually about as trivial as the electron model.

First, **we use the radius of the pion as defined by Eq. 2-3 in the neutron model, above, in order to calculate the circumference of the pion's revolving charge's light speed orbit**. (The "spin 0" particle, as we use it here, has a revolving charge like the electron, and its orbital radius is r_π = 0.18503077 fm.) The circumference of the unexcited pion will be considered to be a single de Broglie wavelength. However, it can be excited during a collision so that the different energy levels are determined by integral multiples of its wavelength for an increasing circumference.

First, we start with the obvious: The de Broglie wavelength of the pion's charge's orbital circumference is

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2\,M\,E}} \text{ cm.} \qquad (3\text{-}2)$$

(The pion's radius is obtained in Section 2 and is r_π = 0.18503077 fm.) Solving for E, we have for the multiple circumferential wavelengths, and hence the multiple energies

$$E = \frac{1}{2\,M}\left(\frac{h}{n\,\lambda}\right)^2 = \frac{1}{2\,M}\left(\frac{h}{\lambda}\right)^2\left(\frac{1}{n}\right)^2 \text{ MeV} \qquad (3\text{-}3)$$

$$E = \frac{1}{2\,M}\left(\frac{h}{2\,\pi\,r_\pi}\right)^2\left(\frac{1}{n}\right)^2 = \frac{4074.3878}{n^2} \text{ MeV} \qquad (3\text{-}4)$$

Thus, we have derived the previously shown meson equation,

$$\mathbf{E} = \frac{\mathbf{4074.3878}}{\mathbf{n^2}},$$

in three easy steps.

These energies, along with their transitions, are plotted in Figure 2-3, below.

(See publications 1, 20, 22, and 25, below.)

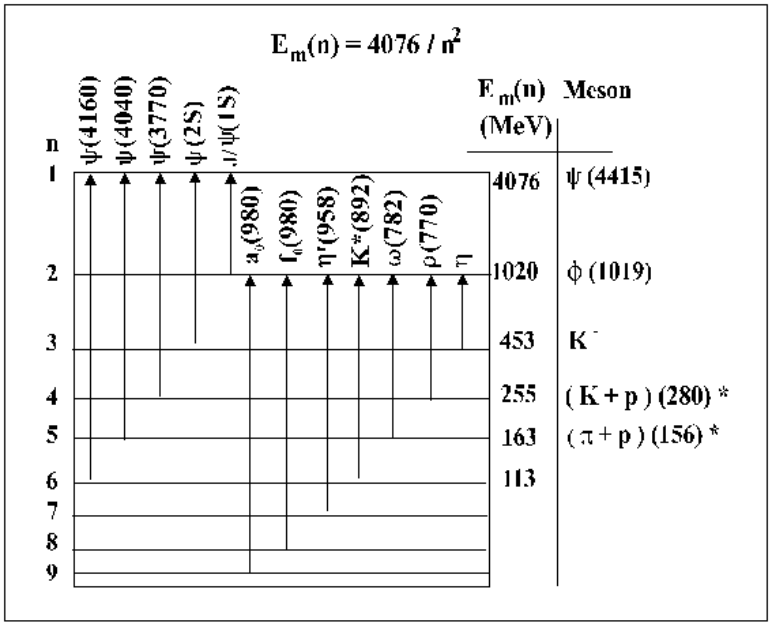


Figure 3-3. This diagram contains 9 of the energy levels as provided by Equation 3.1, above. These are not unlike the Bohr atom's energy levels. Energy level 1 is the "ground state" energy level. The others are the excited states.
3-3a. The first order transitions are the transitions between the various higher energy states and level 1. These would correspond to the Lyman spectra of the Bohr atom.
3-3b. The second order transitions are the transitions between the various higher energy states and the first excited level. These would correspond to the Balmer series of the Bohr atom.

The general wisdom from the Standard Model is that the pion is a "spin 0" particle whose charge could not possibly revolve. But to quote Galileo after his trial at the inquisition, where he was forced to recant his claim that the Earth revolved around the sun, he stated under his breath "Nonetheless, it still revolves!".

Note also that this appears to be a 4074.3878 MeV "glue" that holds the 139.57018 MeV particle together. It is rather strange that this energy does not show up as mass, however.

For lack of a better term, we will call the energy in Equation 3-3 a "de Broglie" energy.

Clearly, based on its role in the neutron model and in the above derivation, it should not be too big a blasphemy to state that, if a direct measurement were made of the pion's magnetic moment, it would be finite and would equal the value given in Eq. 2-3, above. But because of its very small magnetic moment, it should not act very strongly with other particle's magnetic moments other than to neutralize them to some extent or to align with them.

It should also be noted that applying this de Broglie methodology to the proton gives questionable results.

Overall, it appears that the meson family consists of various states of the pion, both within the neutron and in the electron itself.
(See publications 1, 13, 15, 17 and 18 below.)

For the original publications from which the above was derived, see:

1. Ernst L. Wall. "On Tachyons and Hadrons", Hadronic Journal 9, p. 239, 1986.
2. Ernst L. Wall. "Charm, Other Resonances, and the Tachyonic Particle Model", Bulletin of the American Physical Society **33**, p. 1076 (1988).
3. Ernst L. Wall. "On Pion Resonances and Mesons, Time Cancellation, and Neutral Particles", Hadronic Journal **12**, p. 309 (1989).
4. Ernst L. Wall. Book, The Physics of Tachyons, 234 pp., (Hadronic Press, 1995)

©Ernst L Wall 2007, All Rights Reserved

Terminology: vortex electron, vortex electron theory, vortex electron physics, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, vortex muon, meson, vortex proton, vortex neutron, vortex deuteron, solid helium-three pvt surface & melting curve minimum.

3.5. More Mesons: The Binary Mesons

Because many of the mesons studied here arise from relatively large energies that produce two or more pions, we must consider that at least some of these collision should produce energy levels that are the sum of two particles excited mass-energies.

Since the energies can be a combination of any two levels, we combine all possible energies of the lighter mesons (the second order transitions, above) and obtain binary energy levels of the electron-positron collisions.

These binary levels are graphically shown in Figures 3-4 and 3-5, below, along with their corresponding experimental values. Here, the index n arbitrarily picks up from the value n = 9 in the graph above. Both the experimental energy levels and the summed values of the light mesons are arranged in ascending numerical order and plotted. None of the experimental mesons are named here simply because there are too many of them. They are shown in detail in The Physics of Tachyons.

The agreement with experiment ranges from -16 % to + 12 %. While this might appear to be only crude agreement between experiment and theory, it should be noted that no attempt was made to compensate for any binding energies between the positive and negative excited pions.

Further, many of these mesons were not discovered at the time this model was originally developed, so that this model predicted more binary mesons than were know at the time.

There are, however, a number of mesons above the binary set that it does not explain. These are also shown here. No attempt has been made at to account for them at this time, although it is likely that they arise as excitations from an even more massive particle than the pion.

Note that the first 19 binary mesons have a scalloped shape that a reflection of the parabolic shape of the light mesons energy curve. The experimental values, while somewhat crude, seem to correspond to this scalloped shape. The first 20 levels are shown below in more detail to illustrate this shape.

(NOTE: The meson graphs shown below were put together in the 1990s, so many of the mesons detected since that time have not been added as of yet. They will be reworked as time permits.)

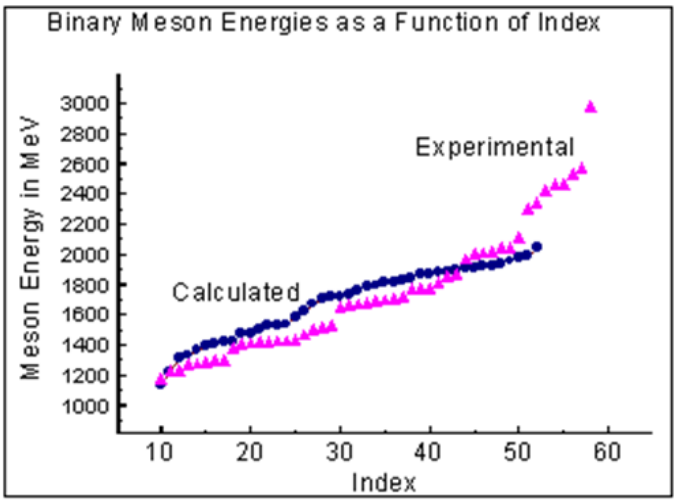


Figure 3-4. The binary pion resonances that arise from electron - electron collisions. The agreement with experiment ranges from -16 % to + 12 %. It is to be noted that the error includes those of the two particles that are combined into one resonance. Further, no particle-particle interactions are considered. If those were included, it is likely that the agreement would be even better. Also, there appears to be a family of resonances that are not accounted for with the present simplistic model.

There is no other model that produces as many mesons and in so simple a manner as this model, especially when you add the binary mesons, as described below.

(NOTE: The meson graphs shown below were put together in the 1990s, so many of the mesons detected since that time have not been added as of yet. They will be reworked as time permits.)

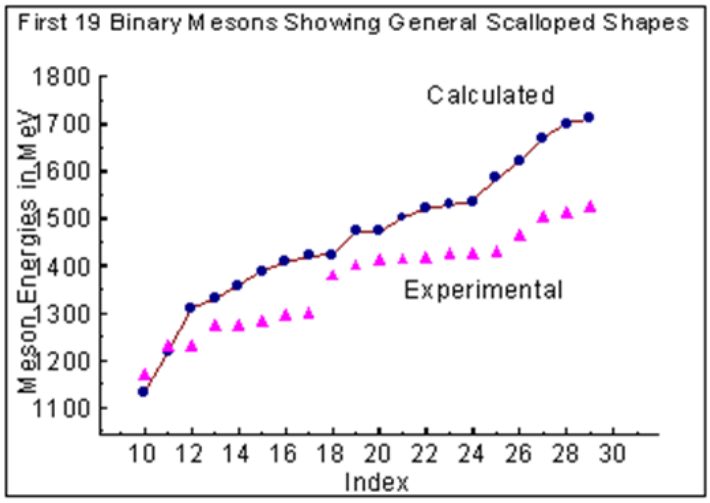


Figure 3-5. Details of the binary resonance masses showing the scalloped shape of the calculated value curves and how they have a semblance of appearance similar to the curve of the experimental particles.

This equation was originally derived from the tachyonic neutron's pion as a set of excitation energy levels, or resonances in a hadron paper. The resonances were sought after in some kaon on deuterons and pions on deuterons with minimal success. These are shown in Section 10, below.

The first 9 levels of the pion, along with their transition energies are shown in Figure 3-3, above.

The first three levels of E_m correspond to the energy levels of the y(4415) , the f(1020), and the K- mesons to within - 8 % to +8 %. The next two levels correspond to resonances that arise from a K → p collision and a p → p collision, these resonances having energies of 280 MeV and 156 MeV, with agreements of -9.3 % and -4.3 %, respectively.

The Standard Model produces nothing like this set of masses from so simple an equation. (If it does, please let me know via the above email address.) Further, we do not use Standard Model parameters such as charm, flavor, strangeness, etc. They aren't needed.

3.6 The Accidental Origin of the Meson Model

It was only after that paper was published that it was realized that these energy levels corresponded to the meson masses. Prior to that, this author had zero interest in mesons because there were so many of them that the possibility of this simple model being a viable meson model would have seemed ridiculous.

Specifically, some weeks after the hadron paper was published the author was reading a Scientific American article on mesons by Weinberg and noted a meson mass that seemed very familiar. He went back and looked in the table shown in Figure 3-6, below, and realized that he had published that meson mass.

The meson energies were discussed in later papers [20, 22].

These models are described in considerably more detail along with those of the electron and muon models in this author's book **The Physics of Tachyons**, 234 pp., (Hadronic Press, 1995).

First of all, note that the Standard Model does not produce such a set of values as does this model, the bulk of them being with 10% of the experimental meson mass values. In fact, some of the other theoretical publications in the early days of meson physics were boasting that they were *within 40% of a single* observed value! (Wow!! What an accomplishment!! 40%!!)

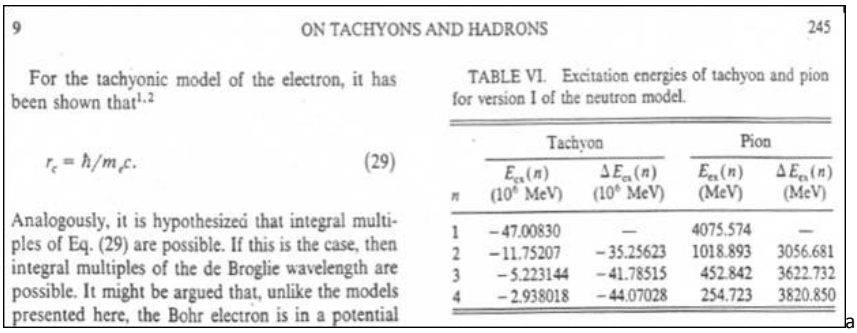
Later, it was realized that the pion, as a parent particle of the electron and muon (within the context of this model), should resonate in the case of colliding electrons, it having an internal binding energy within the context of this model of 4076 MeV. This is, of course, the case in that large numbers of mesons are produced in. In addition, electron-electron collisions produce pions, muons, and gamma rays as would naturally be expected based on this model because the pion is the mother particle of the muon which, in turn, is the mother particle of the electron. (However, it should be noted that one in one thousand pions will decay directly into electrons.)

The most obvious would be the psi resonances. In fact, some of them were originally published in a table of excitation energies in a tachyon-hadron paper (see excerpt from Hadron paper, below), but their significance was overlooked at the time.

The first theoretical prediction of a meson resulted from Hideki Yukawa's proton model which was published in 1935. In 1937 a particle of mass close to that of Yukawa's prediction was discovered in cosmic rays by Anderson & Neddermeyer and in a cloud chamber by Street & Stevenson. These were independent experiments. This particle was, at first, thought to be the Yukawa particle but it was later concluded that it was not the Yukawa particle. 10 years later, Lattes, Muirhead, Occhialini and Powell discovered the pion in a photographic emulsion that was exposed at high altitudes. It was concluded that this was the sought after Yukawa particle.

Still later, other mesons were later observed in various high energy particle collisions as interaction energies, or even as free particles. These resulted typically from pion-proton collisions, K meson-proton collisions, or electron-positron collisions. Some of the earlier and more spectacular observations were made inside Hydrogen bubble chambers. Typically, these reactions produce pions as by products, although K mesons and other mesons are also produced.

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.



9 ON TACHYONS AND HADRONS 245

For the tachyonic model of the electron, it has been shown that[1,2]

$$r_c = \hbar/m_e c. \quad (29)$$

Analogously, it is hypothesized that integral multiples of Eq. (29) are possible. If this is the case, then integral multiples of the de Broglie wavelength are possible. It might be argued that, unlike the models presented here, the Bohr electron is in a potential

TABLE VI. Excitation energies of tachyon and pion for version I of the neutron model.

	Tachyon		Pion	
n	$E_{ex}(n)$ (10^6 MeV)	$\Delta E_{ex}(n)$ (10^6 MeV)	$E_{ex}(n)$ (MeV)	$\Delta E_{ex}(n)$ (MeV)
1	−47.00830	—	4075.574	—
2	−11.75207	−35.25623	1018.893	3056.681
3	−5.223144	−41.78515	452.842	3622.732
4	−2.938018	−44.07028	254.723	3820.850

a

Figure 3-6. Excerpt from paper, On Tachyons and Hadrons [17], showing the original publication of the unrecognized meson energies. These are in the Pion section of TABLE VI. The energies $E_{ex}(n)$ are the excitation energies of the pion. The differences in the energy levels $E_{ex}(1)$ and $E_{ex}(n)$, $\Delta E_{ex}(n)$, correspond to the ψ mesons' energies. In the hadron paper, we listed some searches for these resonances in existing experimental scattering data. These searches are provided in Section 10 as two more figures from the Hadron paper. It was some weeks after the paper was published that it was realized what the significance of these energies was based on some ψ meson energies provided by Weinberg in a Scientific American article.

Also, see Section 10 for some sought after resonances from the hadron paper.

©☐Ernst L Wall 2007, All Rights Reserved

Terminology: vortex electron, vortex electron theory, vortex electron physics, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, vortex muon, meson, vortex proton, vortex neutron, vortex deuteron, solid helium-three pvt surface & melting curve minimum.

==========

4.0. Finally! The Derivation of the Magnetic Moments of the Electron and the Muon by Means of Negative Mass Tachyon Models

In order to produce the results shown above without resorting to ad hoc methodologies, it is necessary to take a contrarian approach to the π → μ and μ → e transitions. Instead of saying that a pion "decays" into a muon and a muon "decays" into an electron, we take the approach that the pion captures a negative mass particle and becomes a lighter muon, and the muon in turn captures still another negative mass particle and becomes an electron. (Note that for those who worry about neutrinos, not only do we acknowledge that they have been observed, we have an appropriate model that we discuss later.)

Note that the dimensions of this model are precisely defined insofar as its spatial and velocity dimensions are concerned. This is an issue that is likely to severely try the patience of any self respecting quantum mechanic. He would assume that any particle such as this must be described by a wave function and that its dimensions could not be precisely determined. More will be said later about why this is not necessarily so within the context of this model even if it is not otherwise obvious from the de Broglie wave model.

The critical issue here is why the electron's charge was assumed to revolve at all, let alone revolve in an orbit having a Compton wavelength as the circumference. The reason was, quite simply, that the tachyonic model and the cutoff energy of the μ → e curve required the Compton wavelength as a dimension, as will be shown below. But note that the tiny charge, in high energy collisions, will still appear to be tiny. The fact that it is revolving will not cause it to appear larger in a scattering experiment than if it were not revolving.

It should be noted that the expression for the magnetic moment is the same as the orbital magnetic moment of the ground state orbit of the Bohr Hydrogen atom. That was first derived by Neils Bohr around 1913. Why these two different states of the electron produce the same magnetic moment is not clear at this time.

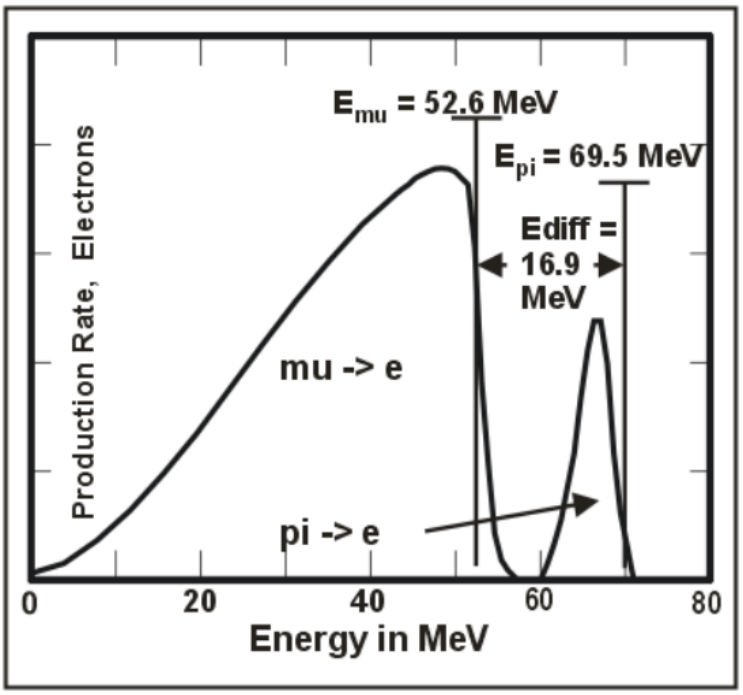


Figure 4-1. This graph shows the experimental transition of rates (relative) as a function of energy for the muon to electron and the rare, direct pion to electron conversions. This graph heart of this model in that the magnetic moments of the electron and muon are obtained directly from the cutoff energies of the two curves.
In fact, from the standpoint of this particular model, the above curves are the most important in all particle physics.
(While the V-A Model describes the μ → e curve quite well, we utilize the cutoff energies here in an entirely different manner.)

Also, note that the use of this curve resulted from a suggestion by Joel Schoen, a physicist who worked at the same company I did in the mid 1980s. After looking at some rather primitive sketches of a model I had written, he commented "Why don't you simply do what everyone else does and find some appropriate energy levels?" At first, that seemed logical on the one hand but absurd on the other hand because there were no tachyon energy levels available! But after thinking about it for a few days, it began to dawn on me that this curve might contain something useful. It was a good suggestion after all! After applying it, my magnetic moment was off by only about 380 times the actual value!! I sent those results to Walter Niblack, a former colleague, who promptly stated that I used a negative mass balance condition (both the dynamic and static conditions) and that would do it. That proved to be the final critical element which was promptly applied, and the results are shown below.

To this author's knowledge there is no other derivation of the Bohr Magneton for the electron spin itself based on its internal structure. That is, there is no other derivation that states that the electron has an internal structure as opposed to being a simple point particle. There are some angular momentum (quantum mechanical) requirements that state that the magnetic moment is given by the Bohr magneton, but no derivation of a revolving particle with a finite orbital radius whose value is obtained from some basic, measured energy level.

However, the fact that the electron's magnetic moment had this numerical value was well known since the early 1920s. This was based on the observations of the splitting of Hydrogen's spectral lines (the fine structure) and the on the Stern-Gerlach experiment.

What was not known at that time was exactly why it had this value.

Also, it should be noted, the magnetic moment as calculated here is somewhat smaller than observed experimentally. To have the correct value, it must be multiplied by the gyromagnetic ratio, $g_e/2$, where g_e= 2.002319394367. This value has been measured out to some 12 decimal places. That is, the Bohr Magneton as calculated here is too small by about 1 part per thousand.

We have no interest in pursuing a one ppt error at this time insofar as it would apply to this model because there are far more interesting things to pursue. Some approaches were taken to earlier to add this correction are described in this author's book, The Physics of Tachyons that is listed below.

We have no further comment on the electron at this time. However, we do note that the same methodology holds for the muon.

Hypothesis: A muon converts to an electron by capturing a negative mass tachyon. A pion converts to a muon by capturing a negative mass tachyon. A pion converts directly to an electron by capturing two negative mass tachyons.

To begin the derivation of the characteristics of the electrons, the masses of the muon's and electron's tachyons are obtained by subtracting the heavier particle from the lighter particle, i.e.,

$$M_{T\mu} = M_{\mu} - M_{\pi} = -33.9091 \text{ MeV} \quad (4\text{-}1)$$

$$M_{Te} = M_{e} - M_{\mu} = -105.147388 \text{ MeV} \quad (4\text{-}2)$$

Next, we will need to utilize half of these masses as binding energies. I.e., we have

$$E_{T\mu} = -16.9546 \text{ MeV} \quad (4\text{-}3)$$

.

$$E_{Te} = -52.573694 \text{ MeV} \quad (4\text{-}4)$$

The sum of these energies is

$$E_{T\mu} + E_{Te} = -16.9546 - 52.573694 = -69.5283 \text{ MeV} \quad (4\text{-}5)$$

The right most curve, the direct $\pi \rightarrow e$ conversion curve, is less well known and describes the relatively rare, direct conversion of a pion into an electron. This event occurs about one in 10^4 pion conversions.

Next, examine Fig. 4-1, above. It is a composite of two particle conversion curves. The $\mu \rightarrow e$ curve on the left is well known and is contained in most particle physics books.

It should be noted that accurate fits to the $\mu \rightarrow e$ curve have been produced by the V-A theory, so that we make no attempt to claim that the positive results of this model invalidate the Standard Model . This model is simply a different approach.

The generally accepted assumption is that two neutrinos are produced by the decay of an electron into a muon, and the shape of the curve is determined by the relative angles of emission of the two neutrinos. That is to say, the curves are normally considered to be decay spectra.

Furthermore, neutrinos have been observed, and the residual energies of this model are 20 eV for the electron model, and 123 MeV for the muon model, more than enough to account for the generally estimated masses of the neutrinos.

The interpretation used here is that the reaction during the capture of a tachyon by a muon has a residual energy whose distribution is described by the $\mu \rightarrow e$ curve. However, if the reaction energy is greater than that of the binding energy of the electron's tachyon to the charged particle, there will be no capture and hence, no electrons will be produced. The point at which this happens, 52.6 MeV, is the cutoff energy of the $\mu \rightarrow e$ curve. This compares favorably with the energy of Eq. 4-4.

But having said that, the possibility of a neutrino carrying away part the energy but leaving a tachyon is not precluded. (See the neutrino model, below.)

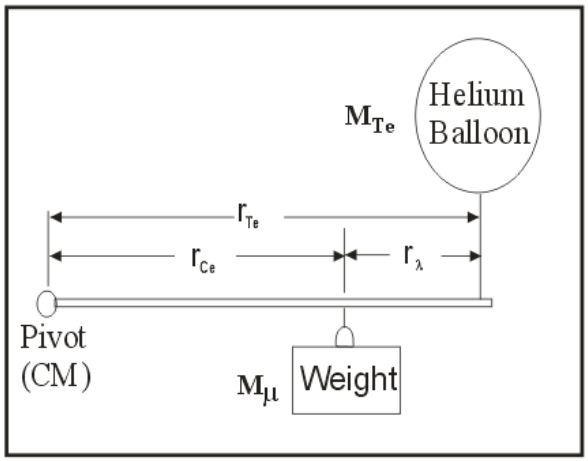


Figure 4-2. This shows an analog for the balance condition that is used to calculate the center of mass for the positive mass charged particle and the negative mass tachyon. Note the use of two parallel strings to attach the weight and the balloon (the negative mass tachyon) to the shaft. Probably the only particle model in which strings have proven to be useful!

Dr. Walter K. Niblack is thanked for pointing out the above balance condition for a negative mass with a positive mass as well as the dynamic balance conditions of Figure 21, below.

The $\pi \rightarrow \mu$ capture, on the other hand, produces monoenergetic muons at an energy 4.119 MeV, so that there is no cutoff energy. Therefore, another approach must be taken. So compare Eq. 5 with the 69.5 MeV cutoff energy of the $\mu \rightarrow e$ curve. The double tachyon capture implies that the total binding energy of the muon and electron's tachyons is half of sum of their masses, and hence, the binding energy of the muon's tachyon is also half of its mass energy. Note, incidentally, that the difference in the two cutoff energies is 16.9 MeV, which is half the muon's tachyon's mass energy as given in Eq. 4-3.

Again, as in the case of the the $\pi \rightarrow e$ conversion, a neutrino is emitted. But in any case, we have no state transition model as of this time that will give the energy balance between the neutrinos and the tachyons.

Because of its negative mass, a revolving tachyon will have an inwardly directed force, not an outwardly directed force. This inwardly directed force of the tachyon balances the outwardly directed force of the orbiting charged particle, thus maintaining the particle systems in tightly bound orbits. The balance conditions are similar to that of a helium balloon (a negative mass analog) on one end of a massless rod balanced by a less massive weight placed between the balloon and a pivot on the other end of the rod. Because of the negative mass, the center of mass of the system is at the pivot, and is thus external to the line connecting the charged particle's orbit and the tachyon. This is shown in Fig. 4-3.

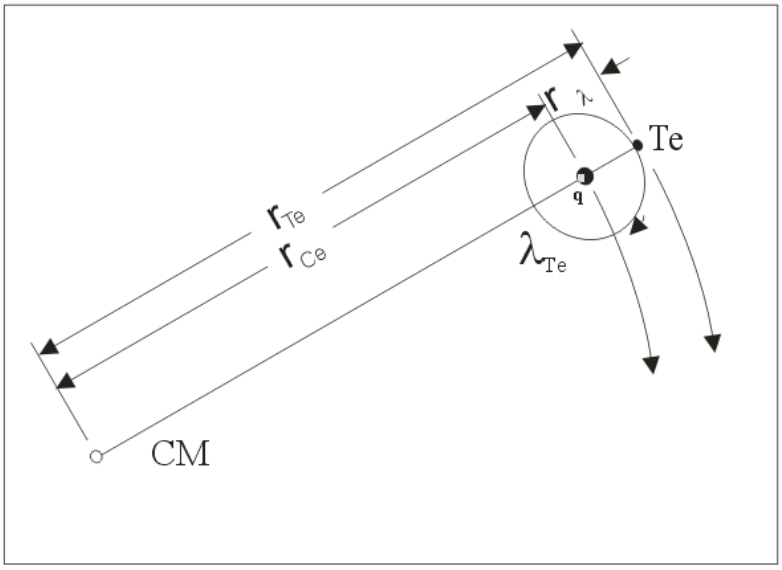


Figure 4-3. This shows the rather bizarre behavior of the electron's revolving charge around the center of mass that is external to the line joining the charge q and the tachyon. From the the tachyon's perspective, it revolves around the charge with an orbital circumference equal to its de Broglie wavelength, λ_{Te}.

Based on the above, in general, the magnitude of the binding energy, which is the same as the ground state energy, is given by

$$E_T = \frac{M_T c^2}{2} \qquad (4\text{-}6)$$

Considering the above, the de Broglie wavelength for the tachyon is given simply by

$$\lambda_T = \frac{h}{p} = \frac{h}{\sqrt{2 M_T E_T}} \qquad (4\text{-}7)$$

where h is Planck's constant, M_T is the mass of the tachyon in grams, and E_T is the energy of the tachyon. Using Eq. 6 for the energy in Eq.7, we have

$$\lambda_T = \frac{h}{p} = \frac{h}{\sqrt{2 M_T \frac{M_T c^2}{2}}} = \frac{h}{M_T c} \qquad (4\text{-}8)$$

It could be argued that it is naive to apply this simple equation to tachyons and ignore relativity. But there is no experimental evidence one way or the other as to how they behave. Certainly it is no more naive than extending the Lorenz transformation to hyperluminal regions and concluding that tachyons have an imaginary mass as has been the accepted practice. Therefore, we will work with what we have and see how the model develops.

If we assume a single de Broglie wavelength, lambda, for the circumference of the tachyon's orbit around the charged particle, we may divide equation 8 by 2 p. This gives us the tachyon's orbital radius, r_{lT}, as it orbits the charged particle in the charged particle's frame of reference. That is,

$$r_{\lambda T} = \frac{\hbar}{M_T c} \qquad (4\text{-}9)$$

Here, the subscript $\boldsymbol{\lambda T}$ refers to the de Broglie wavelength of the tachyon, and $\hbar = \frac{h}{2\pi}$.

While the original model used this concept, another way of looking at it is to consider that both the tachyon and charged particle revolve around the common, external center of mass. The tachyon has some 207 de Broglie wavelengths in its orbit, which is, in this case, larger than that of the charged particles orbit.

We will now explore the balance conditions for a negative mass particle that is coupled to a positive mass. This is illustrated in Fig. 4-3. For the electron, we define

$$R_e = \frac{M_\mu}{m_e} = 206.76826 \qquad (4\text{-}10)$$

For the muon,

$$R_{\mu} = \frac{M_{\pi}}{M_{\mu}} = 1.320932 \tag{4-11}$$

The equations describing the balance of this system for the electron model is

$$M_{\mu} r_{ce} + M_{Te} r_{Te} = 0 \tag{4-12}$$

$$M_{\mu} r_{ce} + M_{Te}\left(r_{ce} + r_{\lambda_{Te}} \right) = 0$$

where we used the fact that $r_{Te} = r_{ce} + r_{\lambda_{Te}}$.

Using Eq. 4-2 (for M_{Te}) in Eq. 4-12, we have that

$$M_{\mu} r_{ce} + \left(m_e - M_{\mu} \right)\left(r_{ce} + r_{\lambda_{Te}} \right) = 0$$

$$M_{\mu} r_{ce} + m_e r_{ce} + m_e r_{\lambda_{Te}} - M_{\mu} r_{ce} - M_{\mu} r_{\lambda_{Te}} = 0 \tag{4-13}$$

The $M_{\mu} r_{ce}$ terms cancel, so that Eq. 4-13 becomes, after a little rearrangement,

$$r_{ce} m_e = \left(M_{\mu} - m_e \right) r_{\lambda_{Te}} \tag{4-14}$$

Dividing both sides of 14 by m_e, and then using Eq. 4-10, we obtain

$$r_{ce} = \left(R_e - 1 \right) r_{\lambda_{Te}} \tag{4-15}$$

Also, rewrite Eq. 2 using Eq. 10 to obtain

$$M_{Te} = m_e - M_{\mu} = (1 - R_e) m_e \tag{4-16}$$

Using Eq. 9 for $r_{\lambda_{Te}}$, Eq. 15 becomes

$$r_{ce} = \pm \left(R_e - 1 \right) \frac{\hbar}{M_{Te} c} \tag{4-17}$$

Using M_{Te} as defined by Eq. 4-16, we eliminate $(R_e - 1)$ and M_{Te} from Eq. 4-17 so that we have for the electron

$$r_{ce} = \pm \frac{\hbar}{m_e c} = 386.15933 \tag{4-18}$$

Using an identical approach for the muon model, the orbital radius of the muon's pion is

$$r_{c\mu} = \pm \frac{\hbar}{M_{\mu} c} = 1.8675947 \tag{4-19}$$

The magnetic moment of a current loop is, in general,

$$\mu = I A \tag{4-20}$$

where I is the current in the loop, and A is its area. (Note that using μ for the magnetic moment is not to be confused with the subscript μ representing the muon.)

Current is, in general, given by the number of charges passing a point multiplied by the charge per particle. Also, recall that in the Gaussian system of units, the charge in statcoulombs divided by the speed of light is the unit of charge used to calculate the magnetic field. Hence, the current at a point caused by a single

charged particle revolving about a center point is

$$I = \frac{e}{c} f \qquad (4\text{-}21)$$

where f is the frequency of the particle's rotation, and for a light speed particle is given by

$$f = \frac{c}{2 \pi r_c} \qquad (4\text{-}22)$$

where c is the velocity of the charged particle and r_C is its orbital radius. Hence, the magnetic moment of a single, revolving charged particle is obtained from Eqs. 4-20, 4-21, and 4-22, as

$$\mu = \frac{e}{c} \frac{c}{2 \pi r_c} \pi r_c^2 \qquad (4\text{-}23)$$

where πr_c^2 is used for the area, A, of the current loop of Eq. 4-20. Eq. 4-23 then becomes

$$\mu = \frac{e r_c c}{2} \qquad (4\text{-}24)$$

Using equation 4-18 in Eq. 4-24, the magnetic moment of the electron is

$$\boldsymbol{\mu_e = \pm \frac{e\hbar}{2 m_e c}}. \qquad (4\text{-}25)$$

Using Eq. 4-20 in Eq. 4-24, the magnetic moment for the muon is

$$\boldsymbol{\mu_\mu = \pm \frac{e\hbar}{2 m_\mu c}}. \qquad (4\text{-}26)$$

These are the Bohr magnetons for the electron and muon respectively. These values for the magnetic moments agree with experiment to within 0.17 % for the electron and 0.12 % for the muon. No particular significance is attached to the plus and minus versions of the magnetic moments at this time.

(Yes, we acknowledge that this is one bizarre methodology!! However, everything on this web page was ultimately derived from these results.)

But to take it a step further, by requiring that the electron's charged particle have an integral number of wavelengths, the accuracy of the electron's magnetic moment is improved to within 39 parts per million. That is, the gyromagnetic ratio is g/2 = 1.0011208. (QED does better than this, but with hundreds or workers and almost 60 years, this should be the normal course of events.)

It should be noted, for contrast, that the self-energy calculation for the electron provides the well known classical electron radius of 2.8179 fm, which is far smaller than that of the electron as given above. However, it is less than twice that of the muon. No particular significance is attached to this, however. But it is interesting to note that if we divide the electron's charged particle's radius (the reduced Compton wavelength) by the classical electron radius, the result is the fine structure constant. Again, the significance of this with respect to this model, if any, is not clear at this time.

One objection that may be raised is that the electron is much larger than the high energy scattering data indicates it is rather small. The electron's charged particle's orbit has a radius of 386.15933 fm, and the muon's charged particle's orbital radius is 1.8675947 fm. In spite of these large orbital radii, the actual scattering cross section of muons and electrons would be expected to be much smaller at high energies because the actual charged particle itself is no larger than the pion. That is, the upper most limit of its radius is 0.185 fm (2.15 Mb). This does not contradict the much lower experimental value of 5 - 30 Nb. (No lower limit is available from the model.)

In the above, we obviously assumed that negative mass tachyons exist based on the results from this current model. However, those tachyons are bound to charged particles trapped in light speed orbits. We do not really know if they are created, say, as “holes” in space when the particle transitions from one state to another, or if they are free particles that are captured by these charged particles. We assume that latter for the moment.

But for the sake of argument we assume here that free tachyons exist. However, we have no idea what their interactions with each other are, or if in fact, there are any. Furthermore, we have no evidence that indicates that they interact with free photons nor any reason to believe that they should in the first place.

In Section 9, we address the issues with synchrotron radiation in the case of a revolving charged particle.

Finally, it should be noted that this entire derivation was initially done numerically on a Melcor (now obsolete) LED display hand calculator. I.e., it was done without algebra because the author was trying to get a feel for the small numbers used in electron calculations. A short time later, it seemed rational to carry out the algebraic derivation shown above.

For the original publications that the above is derived from, see:

1. Ernst L. Wall. "The Role of Tachyons in Electron Spin and Muon Spin", Bulletin of the American Physical Society **30**, p. 729 (1985).
2. Ernst L. Wall. "Indirect Evidence for the Existence of Tachyons; A Unified Approach to the Pion ® Muon ® Electron Conversion Problem", Hadronic Journal **8**, p. 311 (1985).
3. Ernst L. Wall. Book, **The Physics of Tachyons**, 234 pp., (Hadronic Press, 1995)

(See publications 1, 21, 25, and 26, below.)
© Ernst L. Wall 2007, all rights reserved.

Terminology: vortex electron, vortex electron theory, vortex electron physics, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, vortex muon, meson, vortex proton, vortex neutron, vortex deuteron, solid helium-three pvt surface & melting curve minimum.

5.0. A Longitudinal Electric Impulse Field Model of the Neutrino

It is likely that a neutrino is a light speed particle within a few parts per billion. This is based on the fact that the optical observation of the Supernova 1987A occurred within hours of the detection of its neutrinos after a journey of some 163 thousand years. We make this statement without arguments about the time for a photon to travel from within interior the supernova versus the time for a neutrino to travel from the interior. We assume a few hours for both particles because a supernova is a violent event as opposed to a stable star. (It is to be noted that it may take a million or so years for a photon to make its way from the center of a stable star to the exterior because of the scattering.) Based on this, we propose a light speed neutrino model that is consistent with this model.

When a pion converts into a muon, we hypothesize that part of the impulse field is near instantaneously separated from the revolving particle so as to from a longitudinal impulse field that is independent of the electron and that travels outwardly at the speed of light. This results in a neutrino model that is consistent with this particle model. A crude, qualitative illustration of this model is shown below in Figure 5-1.

The details of the E and H fields are shown in the figures below.

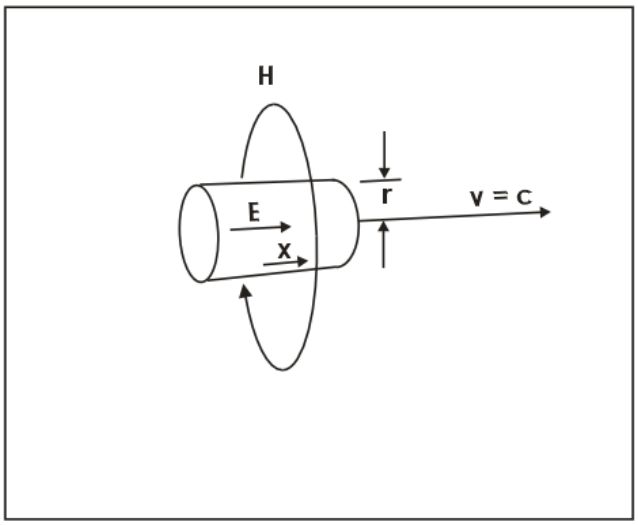
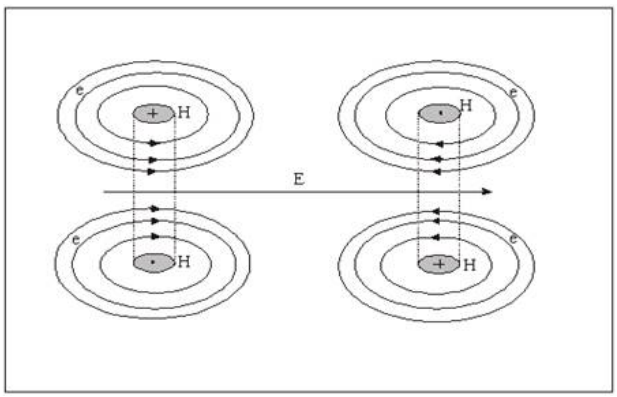


Figure 5-1. This is the fundamental longitudinal electric impulse neutrino model having a radius r. The E field is directed parallel to the velocity vector. At the front and back, where the field is rapidly changing, the cylindrical region is surrounded by magnetic fields



.Figure 5-2. This shows the relationship between the primary E field and the magnetic fields, H, that result from the increasing E field at the front of the neutrino and the decreasing E field at the rear. These changing H fields produce counter emfs, e, that oppose the primary E field in the front and reinforce it at the rear. I.e., they cause it to sort of "bunch up" longitudinally.

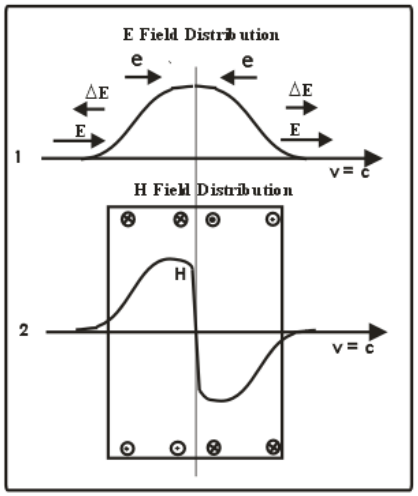


Figure 5-3. This is the graphical version of the fields shown in Fig. 22. Here, we see the E field along the longitudinal cross section of a neutrino. The increasing E field generates a changing circumferential H field. When the E field drops off, it generates an H field in the opposite direction. Also shown is the counter emf, e. We use here a Gaussian E field for convenience.

It should be noted that there is no spin associated with the neutrino model. However, there is a definite orientation with respect to its direction of propagation.

Also, we do not make any judgments as to the direction of emission from the electron with regards to its spin axis. Because experiment indicates that neutrinos have a preferential emission in the direction of the spin axis, we accept that is the most likely emissions direction.

At this point, we propose that the so-called cosmic dark energy is composed of nothing more than these longitudinal neutrinos.

For the original publications that the above was derived from, see:

1. Ernst L. Wall. "A Longitudinal Electromagnetic Impulse Neutrino Model", Bulletin of the American Physical Society **43**, p. 2163 (1998).
2. Ernst L. Wall. "Radial Stability in a Longitudinal Electrical Field Neutrino", Bulletin of the American Physical Society **44**, p. 34 (1999).
3. Ernst L. Wall, "A Longitudinal Electrical Impulse Field Neutrino and its Origin in Virtual Quanta of the Tachyonic Electron, Muon, and Pion", Hadronic Journal **24**, p. 207 (2001).

©☐Ernst L Wall 2007, All Rights Reserved

Terminology: vortex electron, vortex electron theory, vortex electron physics, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, vortex muon, meson, vortex proton, vortex neutron, vortex deuteron, solid helium-three pvt surface & melting curve minimum.

==========

6.0. The Effect of the Vortex Electron's Compton Wavelets on the Dimension of the Bohr Radius to within 52 ppm, Plus Some New Fine Structure Relations.

(The bulk of this section was originally published as:

Ernst L. Wall. "A Study of the Fundamental Origin of the Dimensions of the Bohr Radius of the Hydrogen Atom as Determined by the Quantized Dynamic Electric Field Surrounding a Vortex Model of the Electron." The Hadronic Journal **39**, p. 71, (2016)

Also, see further publications at end of this section.)

6.1. Introduction

The Bohr atom is generally conserved to be obsolete, but is typically presented in a modern physics course as an artifact that is instructive as an introduction to quantum mechanics. However, due the nature of the electron as described in Section 1 of this web page, it is convenient to utilize it here as a basis for studying the interaction of the Compton wavelets inside the hydrogen atom.

Specifically, we will briefly describe the effects of the Compton wavelets on the length of the Bohr radius. The effect is simply that the wavelets reflect off the nucleus and impact back on the revolving electron, thus helping maintain it in a fixed orbit.

If we were to try to utilize this model in conjunction with, say, the Schrodinger equation, then we would wind up with a mathematical development that completely loses sight of the physics of the electron. That is, we are interested here in basic physics, not what might turn out to be a mathematical abstraction.

An application of this model with the Schrodinger model needs to be done, but that will be saved for a later day.

6.2. Electron Units: A New System of Units

We define here some new, natural units of measurement for use in this kind of investigation which we call Electron Units, or EUs. They are:

1. Comptons The unit of length is the Compton wavelength.
2. Rotations (or rotes) The unit of time is the period of a single rotational of the electron.
3. Velocity Comptons per rotation.
4. Mass The mass of a single electron at rest.

An electron rotates at a frequency of

$$\mathbf{f_e = 1.23558996E+20\ Hz},\qquad (6\text{-}1)$$

(see Eq. 1-2) which is calculated from the speed of light (2.99792458E10 cm/s [6-1]) and the Compton wavelength. Thus, it has a rotational period of

$$\mathbf{t_e = 8.09329979E\text{-}21\ seconds.}\qquad (6\text{-}2)$$

We simply call the time period a rotation, or a “rote”.

Of course, the velocity of light that results from this, by definition, is one Compton per rotation.

To put these in perspective with the Bohr hydrogen atom, note that the first Bohr radius of the hydrogen atom is 5.2917721092E−9 cm in length. This is 21.809956634 Comptons, which is the distance from the center of the nucleus to the center of the electron. That is to say, the first Bohr radius has the dimensions of

$$\mathbf{a_0 = 21.809956634\ Comptons.}\qquad (6\text{-}3)$$

But we note that if we simply multiply Eq. 6-3 by 2π, we obtain the circumference of the first Bohr orbit which is

$$\mathbf{2\pi\, a_0 = 137.03599907\ Comptons = C_{Bohr}\ Comptons.}\qquad (6\text{-}4)$$

This, of course, is the fine structure constant expressed in Comptons, and it is also the circumference of the first Bohr orbit.

Normally, of course, the fine structure constant would not have any units, but in this case it does. But more important, it provides another relationship between the Bohr radius and the inverse fine structure constant.

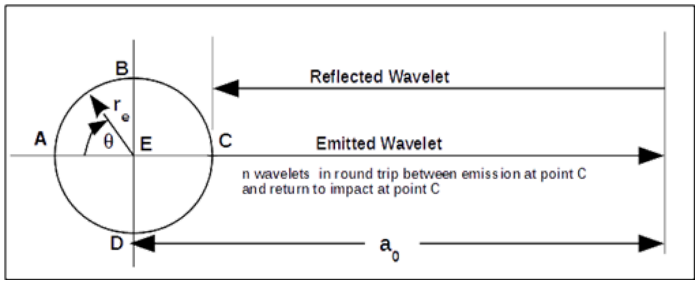


Figure 6-1, A, B, C, and D. For example, here we have a wavelet emitted by the charge at point C, which then travels towards the nucleus and where it is reflected back to the electron. It then impacts back on the charge at point C provided that it has the correct spacing between the nucleus and the electron. The electron will revolve some 43 times before the wavelet returns, which is a round trip distance of 43 Comptons [2 – 6].

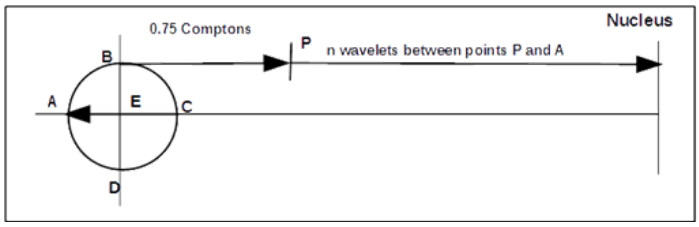


Figure 6-2. This is the most accurate scenario. The wavelet is emitted at point B in a cyclotron fashion. During the time it takes to rotate clockwise from B to A, the wavelet moves 0.75 Comptons. Meanwhile, there is a train of 43 wavelets between the point P and the impact point A.

The equation for the Bohr radius in the above scenario is given by

$$a_0 = f * (0.75 + n - r_e)/2 , \quad (6\text{-}5)$$

where

$$f = 1.00057125788, \quad (6\text{-}6)$$

which is a combination of the effects on the electron radius due to its lowered energy in the potential well.

Table I. The Bohr radius equations, the Bohr radii, and the errors for a number of emission-impact scenarios with two possible values of n for emission from and impacts on cardinal points A, B, and C. Not all of these were diagramed, above, however. Note that while it is not explicitly shown here, we subtract r_p from the radial value. Here we use six decimal values so that we have three significant figures in that value with the least error, scenario B-A, which is shown in red.

Emission Point	Impact Point	Bohr Radius Equation	a_0 (43) (Cmptns)	a_0 (44) (Cmptns)	Delta(43) (Cmptns)	Delta(44) (Cmptns)
A	A	n/2 - r_e	21.354557	21.854843	-0.455399	0.044886
A	B	(0.25 + n + 2r_e)/2 - r_e	21.638874	22.138579	-0.171082	0.328622
A	C	(0.50 + n + 2r_e)/2 - r_e	21.763946	22.262710	-0.046011	0.452754
B	**A**	**(0.75 + n - r_e) / 2**	**21.809394**	**22.309099**	**-0.000562**	**0.499142**
B	B	n/2	21.513803	22.014089	-0.296154	0.204132
B	C	(0.25 + n + r_e) / 2	21.717916	22.218202	-0.092040	0.408245
C	A	(2r_e + 0.50 + n) / 2 - r_e	21.763946	22.264232	-0.046011	0.454275
C	B	(0.75 + r_e + n) / 2	21.968640	22.468345	0.158684	0.658388
C	C	r_e + n / 2	21.673049	22.173335	-0.136908	0.363378

Table II. The fractional error is shown for all scenarios for both the 43 wavelets and 44 wavelet cases for the scenarios of Table I. In addition, we show the calculated value of the inverse fine structure constant based on the 43 wavelet case since that appears to be the most accurate. Note that the fractional error for the B-A scenario is 26 ppm. This value is based on correcting for the potential well using the value in Eq. 6-6. When the relativistic effects are considered, the error is 52 ppm, a reduction in accuracy.

Emission Point	Impact Point	a_0 (43) (Cmptns)	a_0 (44) (Cmptns)	a_0 (43) (Fraction)	a_0 (44) (Fraction)	1/alpha (Comptons)
A	A	21.354557	21.854843	-0.020880	0.002058	134.174640
A	B	21.638874	22.138579	-0.007844	0.015068	135.961058
A	C	21.763946	22.262710	-0.002110	0.020759	136.746905
B	**A**	**21.809394**	**22.309099**	**-0.000026**	**0.022886**	**137.032466**
B	B	21.513803	22.014089	-0.013579	0.009360	135.175211
B	C	21.717916	22.218202	-0.004220	0.018718	136.457693
C	A	21.763946	22.264232	-0.002110	0.020829	136.746905
C	B	21.968640	22.468345	0.007276	0.030188	138.033038
C	C	21.673049	22.173335	-0.006277	0.016661	136.175783

It is not clear whether the effect on the electron is due to charge impact or to a suppression of photon emission, or even both.

At the same time, we cannot show a connection between this particular orbit being choses so that the angular momentum is given by Planck's constant, h. It could have been any integral number of Compton wavelets, not just 43.

Also, this is totally different from what we would have speculated the emission/impact scenario to be in Section 9, below.

6.3. The B-A scenario and a possible vortex electron radiation model

The B-A model (emission at point B and impact at point A) had 52 ppm accuracy after its relativistic dimensional correction. That is to say, the wavelet was emitted at the 90 degree point, reflected and impacted the electron at the 0 degree rotation point. This is somewhat counter intuitive, but nonetheless the accuracy of this scenario as opposed to the others cannot be ignored. Therefore, we must provide a reasonably rational explanation.

The first and most obvious explanation is that the wavelet impacts the charge from inside the electron as it travels past its center and to the periphery.

However, we speculate that another possibility is that at this particular radius and phase, the reflected wavelet suppresses the ability of the electron to radiate. But in order to explain this, we must explain why the vortex electron radiates in the first place. So, to begin, see Figure 6-4

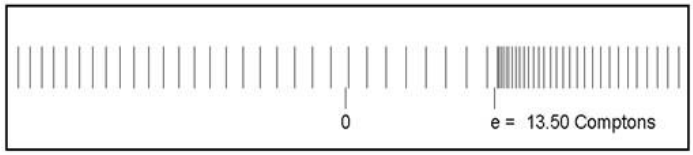


Figure 6-3. The Compton wavelets along the path of an electron that is being accelerating rapidly and linearly towards the right from a velocity of zero up to 0.9c in 30 rotations, where c is the speed of light. It starts from where the electron center is at point 0 up to the point e, where e is the center of the electron an instant of time before emission in the direction of travel. These accelerations and wavelet counts were chosen for illustrative purposes.

We note in Figure 6-4 that as the electron is accelerated towards the right, the Compton wavelets in front of it are compressed and those behind it are decompressed. We define the compressed waves in front of the electron as the frontal wavelets and the decompressed wavelets in back of the electron as rearward wavelets.

As a result of the compression-decompression, there is a differential field across the finite extent of the electron (and beyond) in its direction of travel, this differential field increasing as the electron accelerates. This increasing electric field then generates an electromagnetic wave, or photon.

It is also to be noted, as an aside, that it is a longitudinal electric field in that it is moving in the direction of its electric field vector. Nonetheless, it is a changing electric field, so it would be expected to radiate. We make no further comment on this phenomena at this time.

We also note that, as the electron approaches relativistic velocities, its radius contracts causing its frequency to increase and its Compton wavelets to become even more compressed. We do not show that in Figure 6-4 however.

For convenience in this particular case, we limit this model to the case where the motion is parallel to the electron's plane of rotation. This does not exclude other possibilities, however. (See the case of 2D emission around the circumference of the orbit in Appendix C.)

The most likely mechanism that prevents the electron from approaching the nucleus that we propose here is that when the electron reaches this particular radius, i.e., the first Bohr radius, then the reflected compressed frontal wave overlays the rearward, decompressed wavelets emitted by the electron increases the field strength on the back side of the electron. At this particular radius, the field strength of the reflected wavelets sufficiently neutralizes the radiative field across the electron so as to prevent it from radiating its energy away and approaching the nucleus any further.

More specifically, as the electron revolves at the first Bohr radius, it is constantly being accelerated towards the radius so that the wavelets are slightly compressed on the nuclear side of the electron and decompressed on the outward side. The reflected wavelets have the same ratio of compression/decompression, but are in the opposite direction, and hence, combine with the backside wavelets to increase the backside radiation so as to cancel the radial field across the electron.

Obviously, this is still speculative until such time as adequate simulation and analysis is available to provide some numerical validity to the model. It does not preclude the possibility that a wavelet-charge impact is the actual mechanism. In any case, however, this scenario gives a more accurate agreement with experiment than do the other scenarios.

6.4. The Fine Structure Constant and Some New Twists on Some Bohr Model Numerical Relationships

There are a number of old and well known algebraic relationships that we explore here that were hitherto abstractions. Here, however, we look at them not as abstractions, but as physical relationships between the electron's finite size physical parameters and the Bohr atom's physical parameters.

The first Bohr radius may be defined as

$$\mathbf{a_0} = \frac{\hbar^2}{\mathbf{me^2}} , \qquad (6\text{-}7)$$

But using the expression for the fine structure constant in Eq. 6-7, we may write

$$\mathbf{a_0} = \frac{\hbar^2}{\mathbf{me^2}} = \frac{\boldsymbol{\lambda_c}}{\mathbf{2\pi\alpha}} , \qquad (6\text{-}8)$$

Now using the definition of 1-5 for the electron's radius, 6-8 becomes

$$\boldsymbol{a_0} = \frac{\boldsymbol{r_e}}{\boldsymbol{\alpha}} = \mathbf{137.035999074}\,\boldsymbol{r_e} \qquad (6\text{-}9)$$

This is not a new relationship as was previously stated. However, it is clear here that it has a physical meaning whereas previously it was an abstract relationship with no real physical meaning.

The velocity of the first Bohr orbit's electron is [6-2]

$$\mathbf{v_B} = \frac{\mathbf{e^2}}{\hbar} . \qquad (6\text{-}10)$$

But the fine structure constant is defined as [6-3]

$$\alpha = \frac{e^2}{\hbar c}. \qquad (6\text{-}11)$$

Hence, multiplying 6-11 by c, we find that the velocity of the first Bohr orbit may be written as

$$v_B = \alpha c = \frac{c}{137.035999074} = 2.1876913E+08 \text{ cm/sec.} \qquad (6\text{-}12)$$

That is to say, the velocity of the first Bohr orbit is related to the electron's charge velocity by the fine structure constant.

As we have previously stated in Section 6, the velocity of light is, by definition, one Compton per rotation, so we may write 6-8 as

$$v_B = \alpha = 7.29735265E\text{-}03 \text{ Comptons/rotation}. \qquad (6\text{-}13)$$

Further, we note that we can scale the electron's rotational frequency to that of the Bohr atom's electron's rotational frequency as follows:

$$f_B = \frac{v_B}{2\pi a_0} = \frac{\alpha c}{2\pi a_0} = \frac{\alpha c}{2\pi}\frac{1}{a_0} = \frac{\alpha c}{2\pi}\frac{2\pi\alpha}{\lambda_c} = f_e\alpha^2 \qquad (6\text{-}14)$$

where f_B is the rotational frequency of the Bohr atom's electron, αc is the velocity of the electron in its Bohr orbit, and where we used Equation 1 as the definition for f_e. Hence we have

$$\frac{f_e}{f_B} = \frac{1}{\alpha^2} = 18778.865042\ . \qquad (6\text{-}15)$$

That is to say, for every revolution of the electron around the nucleus, the electron itself will revolve 18778.865042 times, or the period of the Bohr orbit is 18778.865042 rotations. Further, if we use our Electron Units, the period of the Bohr orbit is

$$\tau_B = 18778.865042 \text{ rotations.} \qquad (6\text{-}16)$$

Note that this is not an integral value, so it does not represent quantization of any kind. I.e., it is 7.19 ppm away from being an integral value. It would also preclude the wavelets from taking part in circumferential periodicity, even if they could curve around the circumference of the first Bohr orbit.

Using the electron's mass energy as calculated by the Einstein photo electric equation in Equation 4, we scale its internal rotational energy to its orbital rotational energy in the Bohr atom using equation 28. That is, we divide the electron mass in eV by the numerical value in Equation 28 and we get

$$E_B = E_e\alpha^2 = \frac{E_e}{18778.865042} = 27.21138508 \text{ eV}. \qquad (6\text{-}17)$$

Hence, the revolving Bohr electron's potential energy is determined by the Einstein photo electric equation just as the revolving charge of the electron provides it own mass energy.

The potential energy of the electron in the Bohr atom's ground state is

$$V_B = \frac{e^2}{a_0} = 27.21138498. \qquad (6\text{-}18)$$

The difference between Equations 6-17 and 6-18 is 10^{-7}, i.e., 10 in the last two significant figures, which is within the measurement error of the electron's charge, e [6-1]. That is, Equation 6-13 and Equation 6-14 effectively have the same value.

The Rydberg constant gives the ground state energy of the electron as [6-1]

$$R_\infty = \frac{m_e c\alpha^2}{2h} = 13.60569253 \text{ eV.} \qquad (6\text{-}19)$$

But, half of Equation 6-15 is the same that of Equation 6-16. I.e.,

$$E_B / 2 = 13.60569249 \text{ eV,} \qquad (6\text{-}20)$$

the numerical value of which is within the value 4 in the last significant digit of Equation 6-19, which is acceptable for claiming that 6-19 and 6-20 are equal.

We are justified in using half of Equation 6-14 to compare the electron's mass energy with that of the orbiting electron in the Bohr atom because of the virial theorem. However, in case of the electron itself, there is no known central force holding the electron together, so the virile theorem does not apply there and the electron's mass energy is not divided by 2.

Thus, we relate the finite sized electron's radius, velocity, and circumference to the same parameters for the Bohr orbit by means of the fine structure constant. Further, their rotational frequencies and, hence, energies are related via the square of the fine structure constant.

At the same time, we have previously stated that the electron behaves as if it were a bound state photon, and is related to a similar behavior of the revolving Bohr electron. It too, is bound, but it is bound by an electrostatic potential and it is not a light speed entity.

Or, from another point of view, the rotational energy of the Bohr electron is not an arbitrary value, but it has a definite relationship with that of the electron via the fine structure constant.

Because of the classical approach to modeling the vortex electron that we use here, we do not in any way use quantum mechanics or its concepts at this stage of its development. Hence, there is no intent to make any investigation of any wave mechanics other that of the behavior of the Compton wavelets.

5.5. The Interaction of the Compton Wavelets from Two Electrons

Compton wavelets are much smaller than the de Broglie waves normally associated with them.
To provide a brief graphical illustration of the wavelet interactions, Figure 2 provides the interaction of possible sinusoidal wavelets from two electrons that are moving directly away from each other, the phase distance being measured in Comptons. At the peaks of the envelopes, the wavelets are in phase which indicates that either two wavelets would be crossing, either that, or an electron itself will be impacting a wavelet, depending on the point in space. The peak to peak distance of the envelope is one de Broglie wavelength, but the spatial distant will depend how long it takes the electron to move that distance. Each of the oscillations in the envelope represent a single rotation of the electron.

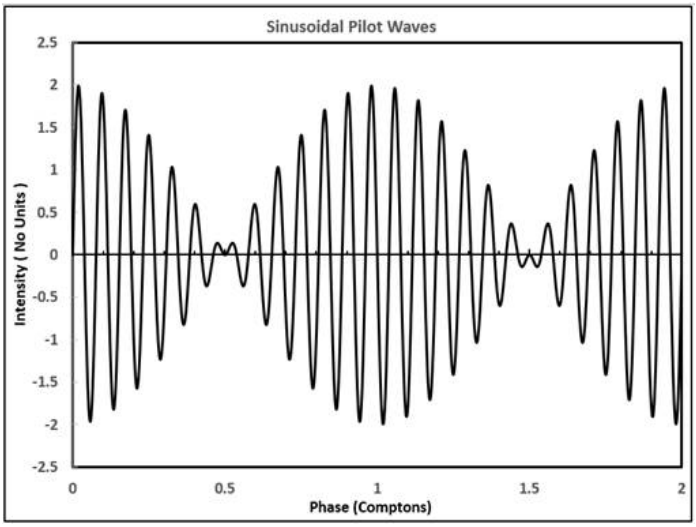


Figure 6-5. **These are obtained by combining sinusoidal Compton wavelets from electrons A and B while they are slowly moving away from one another.**

Having noted that the peak to peak spacing of the envelope is one Compton, we point out that the spacing of the oscillations within the envelope is dependent on the relative electron velocity, so this would require an extreme relativistic particle to produce the spacings as shown here. It is shown this way for illustrative purposes.

In reality at the low energies we use here, the envelopes containing the oscillations would contain a much, much denser set of oscillations representing many more rotations of the electron for the case of a low energy electron interaction.

This wavelet interaction is reminiscent of the pilot waves studied by de Broglie, except that a single frequency is used rather than dual frequencies as discussed by Eisberg for a single particle, and the interference comes from the changing particle spacing, or relative phase change [15]. A good analogy for this particular phenomena is that the relative phases change in such a manner that we obtain an interference pattern similar to that of a Doppler radar.

On the other hand, it is unlike the Fourier analysis over a frequency continuum as provided by Bohm, which provides a wave packet that is localize to a single region of space around some frequency ω_0 [16].

Here, we choose to use the term “pilot wave” for this phenomena after de Broglie. In any case, we make the claim that these wavelets, when they interact, could be considered to be a rudimentary form of pilot waves that arise from a dual particle interaction as opposed to being a single particle phenomena. But their inclusion here is incidental to the real issue, which is the basis we use for de Broglie waves that arise from the Compton wavelets.

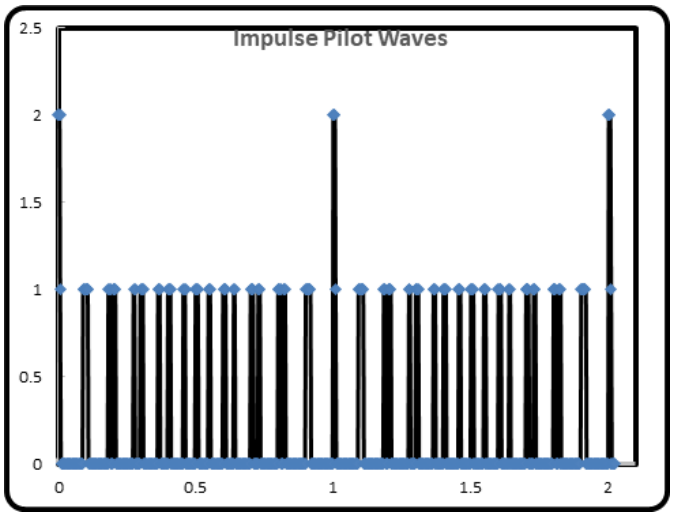


Figure 6-6. Impulse pilot waves obtained by adding a 5 degree wide impulse for electrons A and B and slowly moving them away from one another.

Figure 6-5 is similar to Figure 6-6, but rather than sinusoidal wavelets, we use square, 30 degree width pulse wavelets. When a wavelet crosses another wavelet, or when the electron impacts a wavelet, you get a peak as shown there. That is, it is one de Broglie wavelength from peak to peak. .

Also, Figure 6-2 illustrates the point that for an interaction to take place, the relative phases of the electron and wavelet must be within some finite range and the wavelet must have some finite width at the interaction point. Otherwise, a very precise velocity would be required in order to achieve an interaction.

But having considered all of this, a good argument can be made that the above equations provide a means of utilizing wavelets to provide a fundamental basis for quantum mechanics. However, these are linear equations, and we need to develop a rational for transforming them into a spherical form that will be consistent with a standard quantum mechanical treatment of the atom, namely, the Schrodinger equation.

References:

9-1 J. Beringer, et al. (Particle Data Group), Phys. Rev. **D 86, 010001**, p. 444 (2012).
6-2 Robert M. Eisberg, op. cit., pp. 110 – 124, (John Wiley & Sons, 1961)
6-2 E. U. Condon. **Handbook of Physics,** pp. 7-24 – 7-26 (McGraw-Hill, 1967).

The above is based on the following publications:

1. Ernst L. Wall, "Revisiting the Bohr Atom 100 Years Later", Bulletin of the American Physical Society, **N32.00002**, **58** (2013)
2. Ernst L. Wall, "A Possible Origin of the Fine Structure Constant", Bulletin of the American Physical Society, **59,** New England Section Fall Meeting, **E2.0005**, 2014.
3. Ernst Wall, **"**The Vortex Electron and the Origin of the Bohr Radius and its Fine Structure Constant, and Pilot Waves", Bulletin of the American Physical Society **60**, New England Section Spring, **B5.00026 (**2015)
4. Ernst L. Wall. "Maintaining the First Bohr Orbit Radius by Photon Suppression", Bulletin on the American Physical Society, 2015 Fall New England Section, **NEF15-2015-000044**.
5. Ernst L. Wall. "A Study of the Fundamental Origin of the Dimensions of the Bohr Radius of the Hydrogen Atom as Determined by the Quantized Dynamic Electric Field Surrounding a Vortex Model of the Electron." The Hadronic Journal **39**, p. 71 (2016)

7.0 Comments on using 2D Particle models as opposed to Conventional Quantum Mechanical Models

Quantum mechanics was developed in the first half of the 20th century and has produced incredibly accurate descriptions of atoms. Some of the atomic models have produced results with accuracies as great as 11 significant figures. Even when applied to such a small entity as the deuteron in the mid 1930s, it provided adequate information for Yukawa to predict the existence of the pion as a "glue" that held the deuteron together.

However, here we are able to obtain observables, or calculated values, that agree with experiment without using quantum mechanics and without a Hamiltonian. This is because the fundamental particles, electrons, protons, and pions that we describe here are 2 dimensional, circular entities insofar as the revolving charged orbits are concerned. Further, quantum mechanics has no model for the origin of the electron's Bohr magneton at all!

On the other hand, to put it simplistically, even the simplest atom, the hydrogen atom, is a combination of two particles. It is a 3 dimensional spherical entity with a complex combination of angular momentum states having different possible directions and different possible energy levels, or, if you wish, at least two degrees of freedom. Atoms are described quite elegantly by the Schrodinger equation that, ultimately, has its basis in de Broglie waves. De Broglie waves, in turn, whose origin we described in Section 1.4, are based on multiple Compton wavelets such that they are much smaller than the de Broglie waves.

This is not the case with particles. Their excited states, in transitioning to or from their "ground" states merely involve changes in the orbital dimensions which are a 2 dimensional phenomena that does not involve other particles or 3 dimensions.

But that being said, the flat obits of the charged particles does not mean that the field around them is flat. Obviously, the magnetic field of the electron is spheroidal in shape. Further, based on the wavelet the model of section 7.b, the Compton wavelets are likely not in just the plane of the orbiting charge, but instead spiral outwardly from the revolving charge in a spheroidal manner.

But for any excited states that the particle may produce, they will not involve multiple combinations of sub-states such as those produced for the atom because there is only a single particle with a single degree of freedom. Excited states of the single particles would be distortions of the 3D shape of its field that will be fixed for each excited state.

But most importantly, it will be noted that there is no Hamiltonian. That is because there is no known central force or kinetic energy in the particles. Hence, the only energy is the mass energy (contained in the magnetic field) or, in the case of the meson equation, there is only what could be described as a "de Broglie" energy as described in the derivation of the meson equation in Section 3.4.

Hence, quantum mechanics, based on the results here, does not appear to be an optimum model for these particles. Further, it is quite possible that a totally different spherical wavelet model of these particles might well produce even more information than we have here. However, there is not any such model at this time.

At the same time, we make no claims that what we have here is an optimal methodology. It is simply a particle model that seems to produce numerical values that agree with experiment.

8.0. Additional Comments on the Semi-Classical Revolving Charge Model

To summarize the electron-muon models: These models are Bohr-like revolving particle models that utilize a negative mass tachyon in conjunction with a revolving, *but very tiny (10^{-18} cm diameter or less),* charged *point* particle that revolves in a circular orbit *exactly at* the speed of light. It generates a magnetic moment equal to the Bohr Magnetons.

Note that a negative mass particle is inherently an antigravity particle.

The negative mass tachyon associated with the revolving charged particle has an orbital radius around the center of mass of the system that is larger than that of the charged particle. It is not clear if this tachyon is a captured particle or if the transition from the muon to the electron creates a 'hole' in space or in the electromagnetic field surrounding the particle.

A free pion captures a negative mass tachyon and becomes a lighter muon. The muon, in turn, captures another negative mass tachyon and becomes an electron. This is, of course, very much in contradiction with the standard particle model. That is to say, the pion is the mother particle of the electron and muon.

Because these transitions from pion to muon and from muon to an electron behave like monopole transitions as opposed to dipole transitions, no radiation would be expected of them. This is observed to be the case experimentally. Longitudinal electric field neutrinos are the logical product of the resulting impulse, however.

This is not to say absolutely that it has to be case that the transition from pion to muon to electron is caused by capturing a negative mass tachyon. As one might have noticed in the discussions above, at least some of the mass-energy of the particle is contained in its electromagnetic field and the smaller the radius, the greater the energy of the particle. Hence, comparable changes in the electromagnetic mass appear to contradict the negative mass tachyon model. This is especially true for the proton and neutron models.

However, this model was developed by taking this tachyon approach with results that continually surprise the author himself. Therefore, we use it here as if it were an absolute truth. But irregardless, the change in electron and muon masses due to the change in the trapped electromagnetic field as opposed to the capture of a tachyon is an area that needs investigation.

However, this model was developed by taking this contrarian approach, i.e., the tachyon capture model, with results that continually surprised the author himself. Therefore, we use it here as if it were an absolute truth.

Similarly to the above lepton family, a proton consists of a heavier sigma hyperon (Σ) that has combined with a negative mass tachyon, but one that has a different mass from that of the electron and the muon. Because the conversion curve has no precise cutoff energy, we must use a converse methodology to that of the electron and the muon models. In this case, the magnetic moment of the proton is used to determine its dimensions with the result that the dimensions of the proton agree to within 3% of the experimental dimensions that are determined from both high and low energy scattering experiments.

A proton captures a pion and becomes a neutron which has a smaller magnetic moment than the proton. It is the resonances of this pion that produce the mesons that were described earlier. Further, based on this model, the pion has a very small magnetic moment, very much in contradiction to the standard model that assumes it to be a spin zero. In fact, if a direct measurement of its magnetic moment is made, it is predicted that its magnetic moment will be very close to that of the deuteron.

The negatively charged pion capture by the positively charged proton has associated with it kinetic energy plus either a gamma ray or a neutral pion of comparable energy to the gamma ray. This is greater than can be accounted for by either the introduction of a negative mass tachyon or the change in electrostatic energy when the neutron is formed, so the excess energy would be logically be accounted for by the conventional loss of electromagnetic energy by the pion and possibly by the proton.

But to continue, if there were free standing negative mass particles, they should have been noticed by now. Hence, they either exist in conjunction with a positive mass particle or they are tachyons that interact with the subluminal universe only under special cases, or both. Within the context of this model, the negative mass particle is required to be a tachyon. It could be a case of either capturing an existing tachyon or creating one during the conversion process.

The balance of the revolving charge energy with that of the internal magnetic field has not been investigated at this time.

Finally, the question of synchrotron radiation must be mentioned insofar as why the revolving charge does not radiate its energy away. The classical synchrotron model is covered quite well in Jackson's book, **Classical Electrodynamics**, 2nd Ed. There, it is important to note that the classical electrodynamic model is developed for sublight speed particles, not light speed particles. In fact, the model becomes meaningless for light speed particles.

In addition, synchrotron radiation also supposes an emission of a field from a sublight speed particle in the direction of its instantaneous velocity. But a light speed particle would not emit a field ahead of itself because the particle is moving as fast as the field itself. So again, the synchrotron model is meaningless for a light speed particle.

Beyond that, we postulate that the energy of the light speed charge constitutes a ground state energy that simply does not radiate. Clearly, this is new ground, so if the model produces agreement with experiment, it is worth pursuing it in spite of any preconceived contradictions with previous models.

In addition, we also note that quantum mechanics has been extraordinarily accurate in its description of the atom. Like relativity, it was one of the great achievements of the 20th century. However, the model we present here utilizes only simple quantization and no attempt, as yet, has been made to arrive at a wave function for the internal structure of this particle systems. But in spite of that there is little to place this model in direct conflict with quantum mechanics as it applies to atomic structures, although its very definite structure will undoubtedly be disputed by many quantum mechanics.

Ultimately, however, a logical consequence of developing the electron model's detailed field produces an electrodynamic model of waves that behave similarly to de Broglie waves. This was presented above and should clarify why it is not necessary to develop wave functions to describe this very basic particle model at this stage of its development. That is, the dynamic electric field surrounding the electron appears to be the source of the de Broglie waves that make the quantum mechanics of the atom possible.

But if that is not enough and if the lack of a wave function is bothersome, it should be quite possible to devise a simple wave equation that will fit this model. However, the result might well be a wave mechanical description of the particle that had lost all information about the structure of the particle, but it still might provide some useful insight into the model. Such a model would be well worth investigating at some time in the future.

(See references 1, 10, 12 and 15.)

©Ernst L Wall 2007, All Rights Reserved

Terminology: vortex electron, vortex electron theory, vortex electron physics, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, vortex muon, meson, vortex proton, vortex neutron, vortex deuteron, solid helium-three pvt surface & melting curve minimum.

---

9. Some Additional Comments on the Electric Field of the de Broglie Waves

9.A. The Shape of the Field of a Charged Particle at Various Velocities (This was the model that was believed to hold prior to the Bohr atom study in section 8, above.)

While the model shown below was developed prior to the Bohr atom study and seemingly contradicts it, we are not ready to abandon it yet. We must consider the possibility that both the lateral impulse emission model, described here, holds as well as the cyclotron emission in the case of the Bohr atom. Hence, we maintain this model also.

For the case of the revolving electron charge, consider the field around a charge at three different velocities as shown in Figure 6-1. First is the case of the non moving charge at illustration A. The second, illustration B, is the field around the charge as it approaches the speed of light. Here, the field begins to bunch up perpendicular to the velocity vector. The third case, illustration C, is the extrapolation of the behavior at B to the speed of light. I.e., it would tend to be completely perpendicular to the velocity vector.

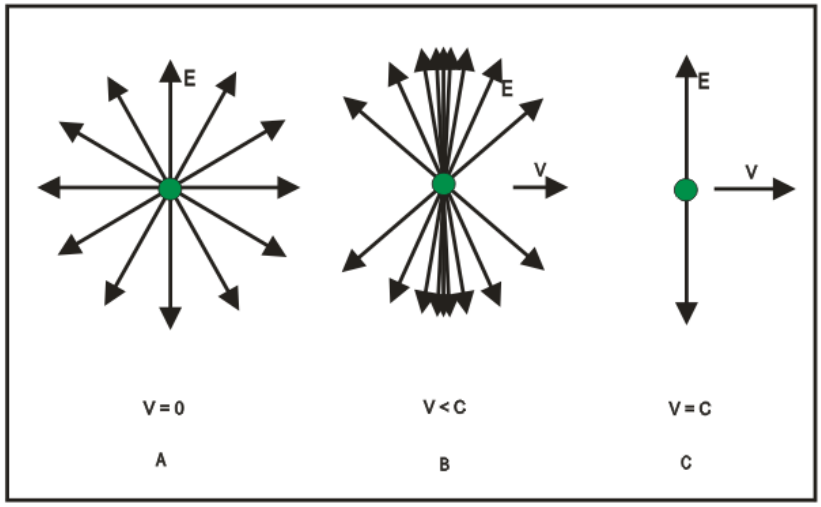


Figure 9-1. Three illustrations of the field around a charge at three different velocities.

9.B. The Shape of the Field Near a Light Speed Charged Particle

Based on the above, and because the electron's charge revolves at the speed of light, the electric field it emits would be expected to be perpendicular to its instantaneous orbital velocity. Because of this, a nearby "observer" would not experience an increasing/decreasing field as the particle revolved, but would experience an impulse from the charge only when it passes by his location. That is to say, the electric field near arising from an electron is not a steady, uniform field, but is instead dynamic field.

Note further, that this would imply an almost circular polarization along the polar axes, to use an antenna analog. Thus, it is quite possible that the detailed behavior of the interaction with wavelets from other electrons is dependent on the polarization of the affected electron with respect to the normal of the wavelet.

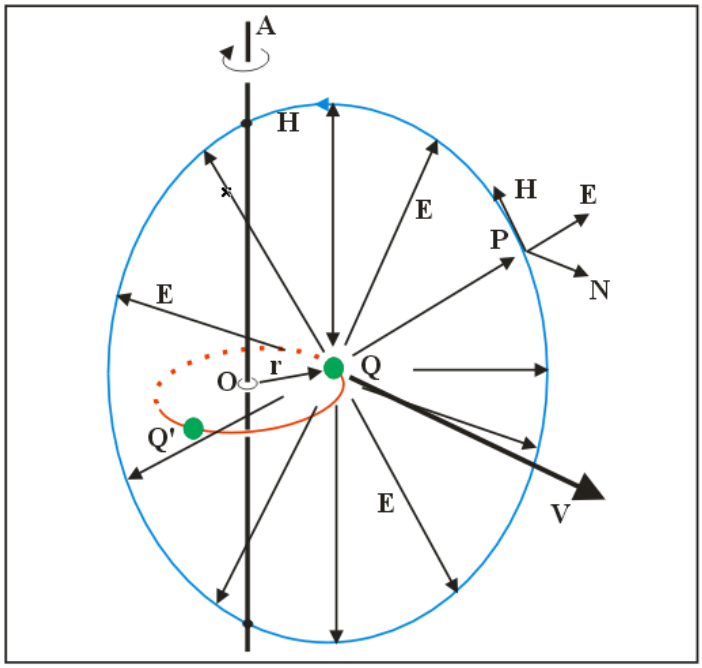


Figure 9-2.
a. This is the three dimensional field of a revolving point charge as it revolves in an orbit of radius r around an axis, A, with a velocity v. The Electric field, E, is emitted at the speed of light at the time the charge is at point Q, and by the time it has reached the point Q' in the orbit, the field has propagated to some boundary, P. The blue circle is the H field, the red circle is the charge's orbit, and N is an instantaneous virtual Poynting vector. We say "virtual" in that it is assumed that there is no net radiation from the field.
b. Note that while the field is shown as a flat plate, it should be more of a conical shape In order to be compatible with water sprinkler/vortex model previously described.

Having described the wavelets emitted by an electron, we now look at a model of how these wavelets might interact with another electron. These are illustrated in Figure 9.3 below. For the case of electron A, the wavelet is approaching the charge from within the orbit, for electron B the wavelet is approaching the charge head-

on. In both cases the wavelets normals are parallel to the electric field of the charges. In these cases, we hypothesize that electrons A and B will receive an impulse from the wavelet.

9.C. How an Electron's Charge Would Likely Interact With an Impinging de Broglie Wave

In the case of electron C, however, the wavelet's normal is not parallel to the charge's field. In this latter case, we hypothesis that there is little or no impulse transmitted to the electron.

As a result of this, an electron in a field of other electrons would experience a cacophony of wavelets passing by with an occasional impulse being acquired from these other electrons as its phase happened to match their phases in a purely probabilistic manner.

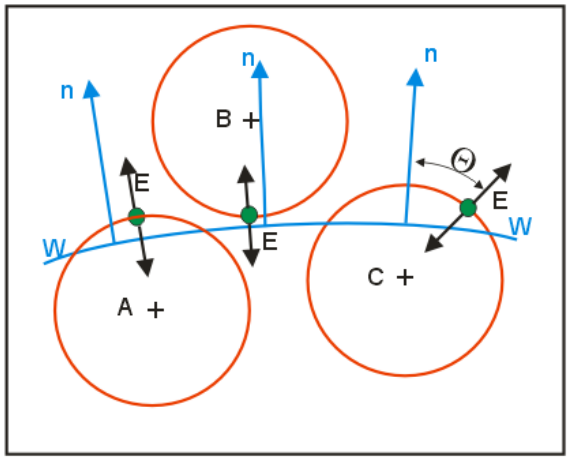


Figure 9-3 Here we have three different electrons, A, B, and C interacting with a wavelet, W, from another electron. The wavelet and its normals are shown in blue, the electron's charge's orbits are shown in red, and the charges themselves are shown in green.

Now that we have described how electrons interact with wavelets from other electrons, we have provide more information on the assumptions we used in the previously presented de Broglie interactions.

9.D A Dot Product Compton Wavelet-Electron Impact model

Finally, we consider another possibility for modeling the impact of a Compton wavelet with the electron. That is, the magnitude of the impulse given to an electron impacting a Compton wavelet is proportional to the dot product of the radius vector to the electrons charge and the normal to the impinging wave. In fact, that would be a much easier to model in a computer simulation.

The above had its origins in the following publications:

1. Ernst L. Wall. "A Possible Fundamental Origin of the de Broglie Equation", Bulletin of the American Physical Society **43**, p. 2163 (1998).
2. Ernst L. Wall. "Electrodynamics of Revolving Light Speed Particles", Bulletin of the American Physical Society, **43**, p. 1399 (1998) .
3. Ernst L. Wall, "Electrodynamics of Revolving Light Speed Particles and A Fundamental Basis for de Broglie Waves", Hadronic Journal Supplement **14,** p. 79 (1999).
4. Ernst L. Wall, "The Tachyonic Electron's Revolving Light Speed Particle as a Non-Radiating, Bound Photon", Hadronic Journal Supplement **15**, p. 419 (2000).
5. Ernst L. Wall, "The Fundamental Electrodynamic Origin of Electron de Broglie Waves", Hadronic Journal Supplement **15**, p. 123 (2000).

©☐Ernst L Wall 2007, All Rights Reserved

---

10. Sought After Resonances from the Meson Equation

These are the figures from the Hadron paper that was published before it was realized that the Meson Equation actually describe mesons.

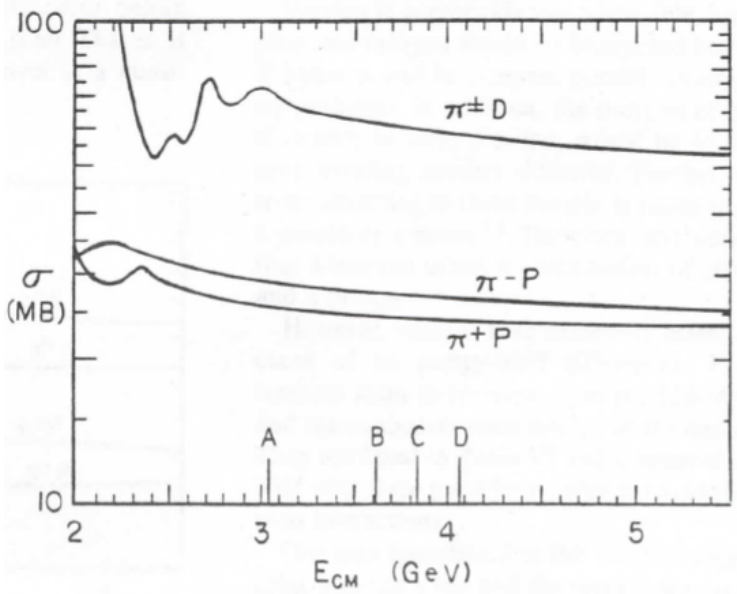


FIG. 6. Scattering cross sections for pions on deuterons and on protons. Note that there is a peak in the pion-on-deuteron curve at 3 GeV, whereas the proton curves are relatively flat in this region. For reference, the version-I pion excitation energies at A, B, and C are 3.057 GeV, 3.623 GeV, and 3.821 GeV, respectively. The energy level at D is the ground-state energy, 4.076 GeV, of the version-I pion.

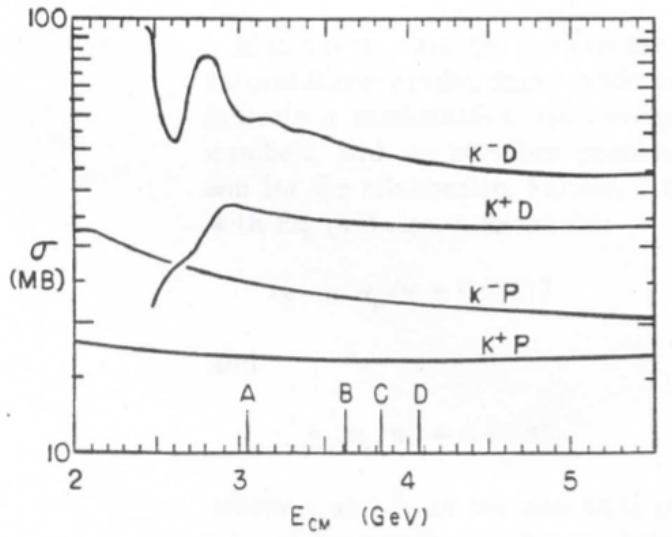


FIG. 7. Scattering cross sections for kaons on deuterons and on protons. Note the rapid increase in cross section of the kaon-on-deuteron curve at 3 GeV. In addition, the peak at 2.8 GeV in the kaon-on-deuteron curve might be a perturbed excitation of the 3.057-GeV excitation. Note the relative flatness of the kaon-on-proton curves. For reference, the version-I pion excitation energies at A, B, and C are 3.057, 3.623, and 3.821 GeV, respectively. The energy level at D is the ground-state energy, 4.076 GeV, of the version-I pion.

The two figures above are from the paper, **On Tachyons and Hadrons** [24]. We were looking for the resonances that are listed in Table VI of that paper, shown in Figure 10 of Section 3, above. However, we had null results in this search except for the small resonance in the π – D curve at 3 GeV. It is indeed strange that the pion resonances fit so well to e-p scattering but do not show up strongly in such simple collisions involving pions. This is especially strange when you recall that the pion is the parent particle of the electron within the context of this model. We propose no explanation at this time.

11.0 Unresolved Issues with the Revolving Charge Particle Models

The following relationships cover, first, some quantitative and contradictory energy calculations along with the questions they raise.

Second, it covers some qualitative contradictions that need investigation.

This material would make excellent Senior thesis or Masters thesis subjects, especially for those interested in computer simulations.

11.1. Some Unresolved Qualitative Issues

In addition to the questions raised above, there are many other questions that could be raised by this model, so we list a few more suggestions to start with, below.

1. We comment that in Eq. 1-2, the use of the number rotations, N, multiplied by q, might at first appear to be simplistic or even in error. However, the final value of the Bohr magneton, μ, has units of erg/gauss. A single rotation of the electron would generate only $1/f_e$ of an erg. Hence, it is necessary to utilize N in Eq.1-2 in order to indirectly get a final total of an erg out of a second's worth of rotations the Bohr magneton in Eq. 1-3. I.e., in electron coordinates as described in Section 6.1 would require that h in cgs coordinates be multiplied by N to convert it to electron coordinates where the time of a single rotation of the electron (a "rote" defines the unit of time and a Compton wavelength (a "Compton") defines the unit of length.

2. The model of the spin ½ of the electron is based on the hypothesis that the mass energy of the electron is uniformly spread across its area. A model of this needs to be developed. A simulation of this might be a viable approach to solving this problem.

3. Similarly, for the revolving pion, its mass as calculated from the revolving photon methodology will be 1066.45 MeV as opposed to the 139.57 MeV measured mass. Clearly there is excess energy that does not show up as mass. Is the wavelength of the orbital "photon" to small to manifest mass? Or is it a measure of the internal binding energy in the manner of a coiled spring?

4. The pion is the mother particle of the muon. It emits part of its wavelet as a longitudinal electric field neutrino and converts into a muon. However, the tachyon model indicates that there is a negative mass tachyon. Might this negative mass tachyon be a "hole" in the wavelet field of the pion?

5. How does this "hole" translate into momentum for the muon that is emitted by the decaying pion? Consider this in as being similar to that of the mass energy relation for the electron when the diameter of the pion increases to that of a muon, thus decreasing the mass of the particle. How does this relate to the longitudinal model of the neutrino?

6. Similarly, the muon is the mother particle of the electron. Is there a "hole" here too?

7. The vortex model of the electron (i.e., the Compton wavelets) was considered only for the wavelets emitted outwardly. However, more recently, when the angular momentum of the electron was calculated, it was postulated that the mass of its disk was caused by the inwardly emitted electromagnetic impulse.
    a. Why is the effective mass contained within the boundary of the electron as indicated by the angular momentum model? Therefore, do the inwardly directed wavelets pass on through the orbit and double the number of Compton wavelets outside the electron's boundaries, or what?

8. The electron's angular momentum model indicates that the mass of the electron is possibly contained in the interior of its orbit. But is this true? Could some of the mass be contained in the wavelets?
    a. The same question should be asked for the pion and the proton.
    b. In light of the above questions, what happens when a sigma hyperon decays into a proton?

9. The Dirac Zitterbewegung frequency is 2 times that of the electron's rotational frequency. What is the significance of that, especially in view of the Compton wavelets?

10. In the meson model: The psi mesons and light mesons are resonances. However, there are mesons that correspond to the discrete energy levels of the meson equation. What is the physical difference?

11. In the case of the "light mesons", all of the calculated values are within 2.3% of the measured values except for the Omega. It is an anomaly that is in error by 9.5%. Why is that?

12. The mass distribution for the electron's angular momentum calculation, Eq. 1-8, needs simulation

13. The general electromagnetic field of the electron needs analysis and simulation.

14. The double slit electron experiment and the Davison-Germer experiment using the Compton wavelets needs simulation.

15. The binding energy of the Deuteron: In light of the Compton wavelet model of the revolving particle, how do the wavelets from the protons interact with each other as well as the pion? Is there a local particle to particle magnetic interaction? This is possibly a good simulation problem.

16. There are other issues discussed in the paper "Unresolved problems of the tachyonic models of the electron and the muon", Hadronic Journal **9**, p. 263 (1986).

17. We have only a minimal real model for the tau meson because there is no measured magnetic moment.

18. We have no models at this time for the W(80.385 GeV) and Z(91.1876 GeV) particles, nor the Higgs boson (125.0 GeV).

19. How does the electron radiate when accelerated? Is the model of compressed/decompressed wavelets suggested in Section 6-2 a viable methodology?

20. In Eq. 1-2, we have the electron's current provided by the number of revolutions multiplied by the charge. However, the reality is that the magnetic field is instantaneous, and the individual impulses do not add up over time. And yet, this model still provides the correct expression for the electron's magnetic moment! However, the speed of light cancels here, so it becomes a non-issue. Perhaps this could be considered to be a form of "renormalization". This concept needs further analysis.

21. The force holding the electron's revolving charge in a circular orbit was originally considered to be the centripetal force of the companion negative mass tachyon. However, it is also worth considering the possibility that an electromagnetic force arises from the curvature and/or a centripetal reaction of the emitted Compton wavelets. This should also be considered in light of the fact that the very small radii of the pion and the muon produce unstable particles, whereas the much larger electron's radius is stable.

22. The issue with the omega(783) in the second order meson equation transitions This is possibly indicative of an issue between levels 2 and 5, or some possible energy aberration in the pion structure or excitation levels that needs analysis.

11.2. Some Energy Calculation Anomalies

Table 5-1, below, shows some relationships between the measured masses of the proton, the pion, the muon, and the electron, and the masses as calculated by two different methods. These methods are:

1. First, we utilize the mass-energy of the electron was calculated by multiplying its frequency of rotation by Planck's constant, h. We refer to this here as a photon mass-energy.

2. Second, we calculated the mass-energies of the particles by setting their circumferences equal to a single de Broglie wavelength in Section 2.4. This energy provided the energy levels that led to the meson equation. We refer to this as a de Broglie mass-energy.

The discrepancies here are large and very interesting, as we discuss below.

Table 11-1. Calculated particle masses. The radii are calculated from the magnetic moments. Photon masses are calculated by multiplying the rotation frequency by Planck's constant. De Broglie masses are calculated by using de Broglie's equation on the particle's circumference, i.e., after the manner of the meson equation derivation in Eq. 2-3, but with n = 1.

Particle	r (cm)	Photon Masses (MeV)	de Broglie Energies (MeV)	Measured Masses (MeV)	Magnetic Moment (ergs/Gauss)
μ_N	2.1030881E-14	938.27193	469.13647	NA	5.05078353E-24
Σ *	5.16939E-14	381.7216970	61.255816	1189.37	1.24148259E-23*
Proton	5.873608E-14	335.955325	60.145654550	938.272046	1.41060762E-23
Pion	1.850308E-14	1066.45494	4074.3878	139.57018	4.443705E-24
Tau **	1.110663E-14	1776.82	888.247889	1776.82	2.667131E-24
muon	1.8675947E-13	105.65835	52.829159	105.6583715	4.4904514E-23
Electron	3.8615933E-11	0.51099895	2.5549946	0.510998928	9.2847701E-21

*The sigma hyperon's magnetic moment is 2.458 mu_N. Its radius is derived from this.
** Tau Lepton data estimated by scaling its measured mass with data from the pion, except for the de Broglie energy

This table contains some extremely interesting discrepancies that need explaining. Some of them are:

If we multiply the de Broglie mass of the muon by 2, we have

$$M = 2*52.829159 = 105.658318. \quad (11\text{-}1)$$

If we divide the electron's de Broglie mass by 5, we obtain

$$M = 2.5549946/5 = 0.51099892. \quad (11\text{-}2)$$

If we multiply the nuclear magneton's de Broglie mass by 2, we obtain

$$M = 2*469.13647 = 938.2729 \text{ MeV}. \quad (11\text{-}3)$$

which is within a few ppm of the mass of the proton.

The most obvious question that would arise from the above is, the fact that the muon ratio is 2 and the electron's ratio of 5, i.e., even and odd numbers, related to the stability of the muon and electron against decay? I.e., why is the electron stable and the muon unstable? For that matter, why is the pion unstable? Also, why is the Nuclear magneton's de Broglie mass half that of the proton?

Finally, if we divide the proton's measured mass by its photon mass, we obtain

$$R = 938.272046 / 335.955325 = 2.792847668, \quad (11\text{-}4)$$

which is very close to the known ratio of the nuclear magneton to the measured magnetic moment of the proton, which is 2.7928456.

The question that arises from Eq. 6-3 is, what is the source of the mass of the proton if it is not electromagnetic like the electron and the muon? We speculate that it is contained in its external field, namely, its Compton wavelets. In any case, this is the most glaring discrepancy in the entire set of models on this page.

11.3. Some Needed Extensions of the Models

1. How does a positron differ from an electron?
2. How does a collision of an electron and a high energy photon generate a positron?

(See publications 1, 24, and 27, below)
©Ernst L Wall 2007, All Rights Reserved

Terminology: vortex electron, vortex electron theory, vortex electron physics, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, vortex muon, meson, vortex proton, vortex neutron, vortex deuteron, solid helium-three pvt surface & melting curve minimum.

==========

12. The Imaginary Mass Tachyon Model

This is section that this author would rather not write because it could be construed as an attack on the very capable researchers that tried to obtain something useful from the imaginary mass model. Nothing could be further from the truth. They have this author's utmost respect and even admiration for their efforts. They were doing their job which is to investigate a possible physical model.

A Religious Icon That is Not Even Wrong!

The internet is filled with references to imaginary mass tachyons. In spite of the fact that an imaginary mass has no physical meaning, one would think their existence is a confirmed fact. "Learned" web pages are filled with algebra that is logically correct and that produces countless pretty graphics. However, none of this leads to any evidence of the existence these entities or to any kind of suggestion of reality.

The imaginary mass tachyon has been around for some 50 years now. In that period of time it has produced nothing that agrees with experiment. (We do note the one exception in Section 12.c where Recami and Mignani derived a negative mass tachyon from it, to put it in simple terms.)

The Emperors New Cloths and a Mindless Clinging to an Unproven Idea.

But in spite of this, this model has become a religious icon that many physicists mindlessly cling to with what can only be described as a death grip that feeds on itself like the case of the Emperor's new cloths.

As a result, any attempted discussion of negative mass tachyons will be met with the mindless insistence that tachyons can only have an imaginary mass to the exclusion of all other models.

The implication is that if you don't believe in the imaginary mass tachyon, you are incompetent and unworthy of your position as was the case with the emperor and the members of his court.

Hence, it seems useful to show why these things are bogus, but with great reluctance.

12A. Why the Imaginary Mass Tachyon is Totally Bogus

First and foremost, there is absolutely no experimental evidence whatsoever to support the existence of imaginary mass tachyons.

The imaginary mass tachyon is derived simply by setting the particle velocity in the Lorenz transformation to a speed greater than c, the speed of light in Eq. 15.1, below. Here, m_0 is the rest mass of some subluminal particle and m is its mass at some velocity v.

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \qquad (11.1)$$

This was originally derived from the results obtained from the Michaelson-Morley experiment that was carried out in 1887.

For subluminal particles, this is known to be correct. That is a fact.

Or course, it is algebraically correct to say that m would be imaginary if $v > 0$. However, by what empirical authority would one say that this is *physically* correct. Furthermore, in the case of a tachyon, what is m_0?

The most obvious reason this is bogus is because:

1. The Lorenz transformation is based on experiments that take place below the speed of light.
2. In the subluminal domain, all particle interactions (based on this model) occur by means of light speed interactions.
3. In the superluminal domain photons cannot catch a tachyon. Further, even if they collide there is no reason whatsoever to assume that a tachyon and a photon would interact, and if they did interact, how they would interact.

But to take bullet 3 further, in the superluminal domain we have no idea what the interactions would be like, if there are any. Certainly there is no experimental evidence of any kind to suggest what they would be like. But whatever they are like, there is no reason to assume that they behave like subluminal interactions.

Worse, according to this model, the energy contained in a particle whose velocity is just above light speed is greater than that of a particle moving at an infinite velocity.

Hence, there is utterly no a priori justification whatsoever to believe that extending a subluminal model to the superluminal domain is valid. In the light of its failure to produce experimentally verifiable results, it is clearly a bogus procedure.

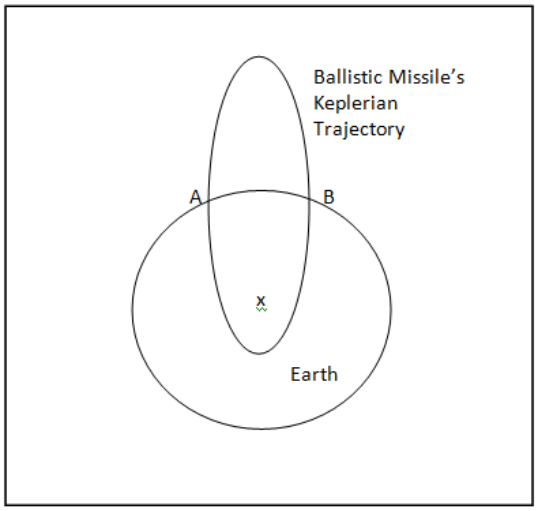


Figure 12-1. A ballistic missile launched from point A on the Earth would follow a Keplerian trajectory to point B at which point it would strike the Earth. The trajectory's focus would be at the point x, the center of the Earth.

a. While the calculation of the trajectory of the missile above Earth would be carried out using a Keplerian orbit, that model would not be correct once it strikes the Earth.

b. Likewise, the Lorentz transformation is totally valid below the speed of light, but it has no meaning above the speed of light.

A more concrete example of such a bogus procedure is shown in Figure 12-1. Here, the Keplerian trajectory of a missile launched from point A to point B would be modeled using an elliptical orbit with its focus at the center of the Earth. Clearly, that model would no longer be valid from point B onward unless you believe in the imaginary mass tachyon.

If you believe that the imaginary mass tachyon model is a correct tachyon model, then you have to believe that the ballistic missile would continue in its ballistic trajectory through the interior of the Earth. It is highly likely that geologists everywhere would welcome your model because they could use it to insert probes into the Earth's interior to study it, especially the core!!

In any case, if anyone has any experimental evidence to support the existence of imaginary mass tachyons, or the validity of the extended Lorenz transformation, this author would like to see it. An email address is provided at the top of this page, so please, I implore you, let me know about it.

Finally, we note that Recami and Mignani did show back in 1972 that the imaginary mass would manifiest itself as a negative mass particle in the subluminal world. This was used as a justification in the original publication of the tachyon model. However, beyond that, the imaginary mass tachyon is of no value.

12.B. The Origins of the Imaginary Mass Tachyon

The extension of the Lorentz transformation to superluminal velocities was first published by Bilaniuk, Deshpande, and Sudarshan in 1962, some 50 years ago. (This is frequently called the extended Lorentz transformation.) That was not an illogical approach for a first cut at attempting to prove the existence of tachyons, and these authors are to be commended for their originality.

Further, these authors were the pioneers that started the faster-than-light movement in the physics community. They have truly earned their rightful place in the history of physics.

In the time since then, probably hundreds of papers based on the extended Lorentz have been produced by many very capable investigators. But in all of that time, and in spite of the obvious capability of those authors, no agreement with experiment whatsoever was achieved. On reading these papers, the impressive capabilities of the authors is manifest, and if these capable people were unable to achieve any experimentally verifiable results, then clearly the model has failed.

It goes without saying that reasonable agreement with experiment is necessary for a physical model to be considered viable, and the imaginary mass tachyon is certainly not exempt from this rule.

But before continuing, we would like to state that the comments here are not intended to criticized or demean any of the many capable workers that have worked with the imaginary mass tachyon. They were doing what a researcher is supposed to do: They were investigating a proposed model in order to determine if it had any validity, a procedure that is nothing less than good science in itself. They gave it a maximum effort. These workers, especially Bilaniuk, et. al., (the authors of the imaginary mass tachyon) should be applauded for their efforts. In fact, this author himself spent some time attempting to apply that theory, but to no avail.

It could be argued that a few papers might have produced a vague suggestion of physical reality, for the most part there have been little or no specific models that could be compared with experiment. I.e., it would not be totally incorrect to say that the imaginary mass tachyon is “not even wrong”.

As to the “not even wrong” phrase, this was used by Wolfgang Pauli. Pauli was noted for his frequently blunt and uncomplimentary assessment of other people’s work. “That is ridiculous!”, he would exclaim. However, in one particular instance someone asked him what he thought of a paper that he was reviewing. “Its not even wrong!”, he said in referring its lack of a model that was testable through experiment. This same phrase was utilized as a title by Woit in his book that discusses the failure of string theory to produce anything that is testable via experiment.

Because the imaginary mass tachyon has never produced any significant theory or model that was testable by experiment after 50 years, it is appropriate to use Pauli’s phrase here.

Regardless of the validity or lack of validity of the extended Lorentz transformation, we simply state that if one simply posits a negative mass tachyon and uses it to develop a particle model, then one can show that that model can produce agreement with experiment. We are not required to extend relativity into a domain in which it has no empirical validation. We have demonstrated that above.

Again, this is said with all apologies to the very talented and capable investigators that have worked in this area and tried to obtain something from it.

12.C. The One Case Where There was a Successful Utilization of the Imaginary Mass Tachyon to Derive a Negative Mass Tachyon

It was published in Rivista Del Nuovo Cimento 4,209 (1974) by Recami and Mignani. Those authors showed that an imaginary mass tachyon would manifest itself as a negative mass (gravitationally repulsive) particle. That was used as a justification in this author’s publication of the derivation of the electron’s and muon’s Bohr magnetons [25].

Back in the mid 1970s I was interested in faster than light phenomena, including tachyons. Because I was working in the semiconductor industry at the time, I was also interested in electrons. At some point, I got this bug in my head that I could use tachyons to model an electron. Specifically, I felt I could model an electron as a muon and a negative mass particle. However, since a negative mass particle had never been detected, if one existed it would have to be a tachyon merely because that was the only way it would not have been observed. Publishing something like that would have been difficult because getting it past the referee would have been problematic.

About that time, Walter Niblack found their paper and gave me a copy of it. That was encouraging, and so in the mid 1980s I had some spare time and developed the electron and muon models. With Recami and Mignani’s paper, I had the justification I needed for publication of my results.

©Ernst L Wall 2007, All Rights Reserved

---

13. The Non-Standard Particle Model

Having seen the model and how well it works, the reader should now be in a position to evaluate it on its own merits. Obviously it is a totally different approach to modeling subatomic particles from previous models. While it is a departure from tradition, it maintains agreement with experiment, which is the only criteria that such a model should be judged on. I.e., how well does it agree with experiment, not how well it agrees with another model.

Noting that we produced observables without resorting to flavor, you may, if you wish, consider this to be a truly tasteless particle model. Because we do not discriminate among particles based on strangeness or color, you may call it a politically correct particle model. Furthermore, there is nothing strange here. It is all perfectly rational and logical, and obviously so. There is no charm to hold things together here because we did not need to consult a shaman, warlock, wizard, or witch. (No smoke and mirrors, either.) There are few parts to these particles and they are cohesive enough on their own, thanks to electromagnetics, so that it wasn’t necessary to purchase any gluons to patch the model together. Finally, it was felt that any quark that was compatible with this model was probably larger than a barn, so even if we had a small barn there would be no place to keep such a critter even if we wanted one.

---

14. A Summary and Some Final Comments

We make no claims that his model as a finished product. It is, in fact, a skeleton that needs fleshing out. We state merely that we have explored the possibility of using negative masses to describe the characteristics of known, quantifiable subatomic particles.

By using the cutoff energies of the $\pi \rightarrow \mu$ and $\mu \rightarrow e$ transitions we have provided a derivation of the magnetic moments of the electron and the muon. That gave rise to a proton model and and then a neutron model that provides a viable, single equation model for the meson energies from the h up through the y mesons. To this author's knowledge, there is no other model that provides so many energies from so simple an equation.

It is also shown that it is possible to calculate the binding energy of the deuteron purely as an electromagnetic phenomena, albeit in contradiction to the generally accepted nuclear force model.

However, this model does have several clear outstanding issues that need resolution. Some of the unresolved issues are as follows:

Equations 1-1 - 1-4 imply that the energy of an electron is contained in the electromagnetic field of the revolving charge. But at the same time, the model was derived on the basis of the balance condition of a positive mass point charge and a negative mass point charge having different spaces from the center of mass. (See Figures 20 and 21 as well as Equation 12-15.) This is a contradiction that needs to be resolved. But in spite of this, it is important to point out that if a model based on an abstraction such as the data from Figure 22 produces the correct magnetic moment of a particle, that would seem to be more than a coincidence. Further, if treating the same model as a trapped photon correctly describes the mass of the particle, that too has to be more than coincidence. Otherwise, these are two very strange coincidences indeed.

A second unresolved issue is an extra peak predicted near the zero degree direction in the case of the Davison-Germer experiment. They saw no such peak. But yet, we feel that the understanding of this different approach to de Broglie waves is compelling enough that it warrants further exploration.

Finally, there is also the case of the narrow revolving electric field lines associated with the de Broglie waves. These narrow revolving lines, as opposed to a continuum electric field, would make the modeling of the binding energy of the deuteron as calculated in Section 3 somewhat problematic. This is an issue that warrants reconciliation.

In spite of the contradictions, however, we assert that continued development of the model is advantageous to understanding the physics of particles because the insight that it offers on top of that of the standard model.

We must ask the following: If de Broglie waves are external to the electron and proton, why would one assume that the quantum mechanics that works so well for atoms is necessarily is the appropriate methodology to apply to subatomic particles? We state here that something other than conventional quantum mechanics would be more suitable for particle analysis. There is a past precedent to this in that classical mechanics, which had proven to be so accurate when applied to macroscopic bodies, proved to be the wrong model to apply to atoms. Quantum mechanics was needed for the atom.

Finally, we have proposed that dark matter is really mass due to longitudinal neutrinos such as the one we have described here.

---

15. A Brief Comment on Constants and Units

For those with minimal experience with subatomic particles, a few comments should be made on the mass terminology used here. For example, the mass of an electron is 9.1093896 x 10^{-28} grams. But this is a little clumsy for human beings to deal with on a daily basis, especially verbally. It is easier to express the mass in terms of electron volts, which for the electron is 0.511 MeV, where MeV is an abbreviation for million electron volts. Further, the early particle accelerators, such as the Van der Graaf generator and the Cocroft-Walton machine used high voltages to accelerate the particles. From this an electron volt was defined as the amount of work done when a charged particle moves through a potential of one volt. Hence, it was natural to express the energy in terms of the voltage with which the particle was accelerated.

The equivalent mass energy relationship is obtained from the Einstein relationship, namely $E = mc^2$. To calculate E, we use the particle mass in grams along with the speed of light which is c= 2.99792458 x 10^{10} cm/sec. The resulting energy, E, is in ergs. However, from electrodynamics we know that one erg is equivalent to 6.24150636 x 10^{11} eV, where eV is the abbreviation for electron volts. Hence, the calculation is quite simple, so the reader should have a try at it with his hand calculator.

Table 16-1. Particle Masses [1]

Particle	Mass (gms)	Mass-Energy (MeV)	Magnetic Moment (Ergs/gauss)
electron	9.1093896x10^{-28}	0.51099906	9.2847701x10^{-21}
proton	1.6726231x10^{-24}	938.27231	1.4106076x10^{-24}
neutron	1.6748286x10^{-24}	939.56563	9.6623707x10^{-24}
muon	1.8835327x10^{-25}	105.658387e-24	4.4904514x10^{-23}
pion	2.488018x10^{-25}	139.5675	4.3x10^{-24} (No, it's not zero, quantum mechanical spin 0 or not.)
Deuteron	3.3435860x10^{-24}	1875.61339	4.3307375x10^{-24}

Table 16-2. Physical Constants [1]

Constant's Name	Symbol	Value	Unit
Speed of light	c	2.99792458x10^{10}	cm/sec
Elementary Charge	e	4.80320680x10^{-10}	statcoulombs*

Elementary Charge	e	$1.60217733 \times 10^{-19}$	coulombs
Planck's Constant	h	$6.6260755 \times 10^{-27}$	erg-sec
Planck's Constant/2p	h	$1.05457266 \times 10^{-27}$	erg-sec

Nuclear and subatomic dimensions are usually expressed in fm, which can stand for Fermis, which is10^{-13} centimeters, or femtometers, which is 10^{-15} meters. (Obviously the same length, but different units.)

[1] J. J. Hernandez, et. al., Phys Letters 239B (Holland) (This is the bi-annual Review of Particle Physics published by the American Physical Society's Particle Group.)
©Ernst L Wall 2007, All Rights Reserved

---

16. How to Obtain Detailed Information on the Tachyon Model

The negative mass tachyon is described in various publications by Ernst L. Wall in the standard physics literature. It is also described in the 241 page book, The **Physics of Tachyons**, Ernst L. Wall, 1995, ISBN I-57485-001-6. It is published by the Hadronic Press, 35246 US 19 North #115, Palm Harbor, FL 34684, USA. Phone: (813) 934 - 9593.

©Ernst L Wall 2007, All Rights Reserved

Terminology: vortex electron, vortex electron theory, vortex electron physics, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, vortex muon, meson, vortex proton, vortex neutron, vortex deuteron, solid helium-three pvt surface & melting curve minimum.

Referenced Terms and Names

Vortex electron, tachyon, tachyons, negative mass, fine structure constant, negative mass tachyon, spin angular momentum, de Broglie wave, mass energy, photon, neutrino, electron, Bohr magneton, magnetic moment, muon, meson, proton, neutron, deuteron, solid helium-three pvt surface & melting curve minimum.

©Ernst L Wall 2007, All Rights Reserved

Note that all of the material, concepts, and ideas expressed on this page and within the reference material by Ernst L. Wall is copyrighted. In addition to the general copyright of the material described: this copyright specifically includes the concept of the revolving light speed charge, the magnetic field it generates, and its contribution the particle mass both in the stationary case and the relativistic case insofar as it applies to subatomic particles and nuclei. This copyright includes the term "longitudinal electrodynamic electric field neutrino" as well as the concept of the neutrino described here. This copyright includes the concept of the electrodynamic wave model of the de Broglie waves and the specific term "Compton wavelet" and the concept of auto correlated wavelets and their reflection off of nearby lattice sites and nearby slits, edges, and surfaces. This copyright includes the tachyonic meson model, the meson equation, the tachyonic electron and muon model, the tachyonic proton and neutron model, as well as the small nuclei models bound together by electric and magnetic fields. This copyright includes the concept of negative mass tachyons. This copyright includes the concept of and use of a state machine to investigate the flow of time.
However, this material may be freely quoted provided full credit is given to Ernst L. Wall.

==========

17. The First Direct Measurements of Solid Helium-Three's Melting Curve Minimum and its PVT Surface

Ernst L Wall

From Thesis for Masters in Science

The University of Florida

April, 1965

Sometime in my first year at Florida I was looking around for a thesis topic, and I approached Dr. Dwight Adams who was a cryophysicist (specifically, a helium-three) and asked what he had that I could do. His immediate suggestion was "See if you can devise a way to measure the compressibility and thermal expansion of solid helium three. No one has ever been able to figure out how to make these measurements inside a cryostat. Here is the cryostat", he said pointing to a really interesting Erector set kludge in the middle of the lab. The kludge had a piece of apparatus (a small Dewar) hanging down that could contain liquid helium-four and that went inside a long, narrow Dewar that contained liquid nitrogen that surrounded the helium-four.
The Erector set supported a maze of glassware for containing and moving the helium-three. The primary movement of the gas was carried out by a toeppler pump, a kludge whereby mercury is used to force the gases from one container to another. This was something I had to have a go at. Furthermore, to an old redneck farmer who had grown up around various pumps with the attendant pressure gauges, the solution was obvious.

I told him "We can hang a capacitor plate on a bourdon gauge and measure the movement caused by temperature and pressure change by measuring the frequency change in an oscillator which we can make using a tunnel diode."

Helium-three had been around since the mid 1940s and was a by-product of the war time atomic bomb development. Here, some 20 years later, no one had figured out how to make such a simple measurement. One can only surmise that was because electronics was not taught to physicists to any great extent, and they didn't learn it on their own *.

That was not the case with me. In addition to being intimately familiar with the innards of pressure gauges (my grandfather was the local plumber, electrician, and water pump expert in addition to being a farmer), I had grown up as an electronics freak, having learned how vacuum tubes work when I was in the fourth or fifth grade. I was later able to "liberate" some electronics books from an uncle who had graduated from World War II and went to electronics school on the GI bill. Later, while in high school, I liberated an Air Force radar training manual from another uncle so that by the time I graduated from high school, my knowledge of radio and radar circuitry from a theoretical point of view was about as good as that of an Air Force radar technician from what I could judge.

Also, I worked at Cape Canaveral for a year and a half before coming to the university, and there I developed an interest in various strain gauges that were used to evaluate aircraft under test, so this fell right into my prior experience as an electronics freak.

In any case, after listening to my suggestion, he showed me the existing sample chamber that went down inside the cryostat. It was about half an inch long and had an inside diameter of about one eighth of an inch, if memory serves me correctly. That was a big "Oops!!" moment.

There simply wasn't enough helium-three to fill a bourdon gauge, so he suggested that instead of using a bourdon gauge, we should hang a capacitor plate on the end of the existing sample chamber. After we talked about it for a few minutes, I put some sketches together and we agreed on what needed to be done. I then made some more precise drawings which I took to the machine shop (I didn't have the time to do the machining myself.) The drawing of the final product is below. (For the younger generation, this was in the days long before computer generated graphics, so every drawing had to be done by hand.)

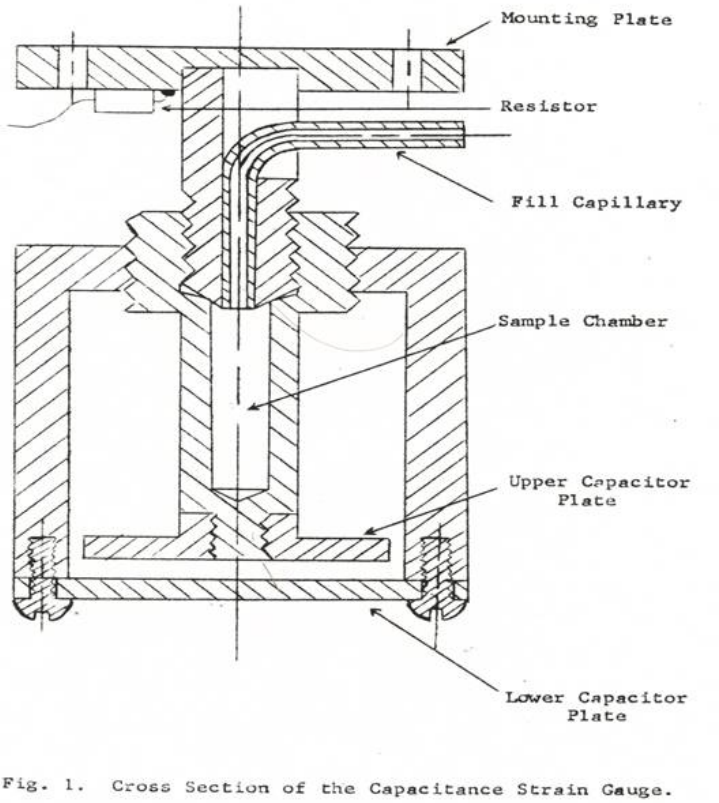


Fig. 1. Cross Section of the Capacitance Strain Gauge.

Strain gauge: By measuring the capacitance of the two plates as a function of pressure at liquid helium temperature, it was possible to calibrate the gauge.

Later on, we put it on the cryostat and I built an oscillator using a tunnel diode with the capacitor plates down inside the cryostat. This was about the most unstable piece of junk one could possibly imagine. Whoever was advertising tunnel diodes for use in oscillators turned out to be a charlatan. I then decided to build a vacuum tube oscillator which I knew to be stable, but then Dr. Adams came in the lab with a General Radio precision capacitance bridge that he had "liberated" from another professors lab. (Looted, perhaps?).

We hooked up the bridge to the capacitor, put some pressure in the chamber, and easily detected a small pressure changes. We were now ready to go so that, within a few weeks, we had some preliminary measurements of the melting curve minimum, the compressibility, and the thermal expansion coefficients.

Some of the final measurements from my Masters thesis are shown below.

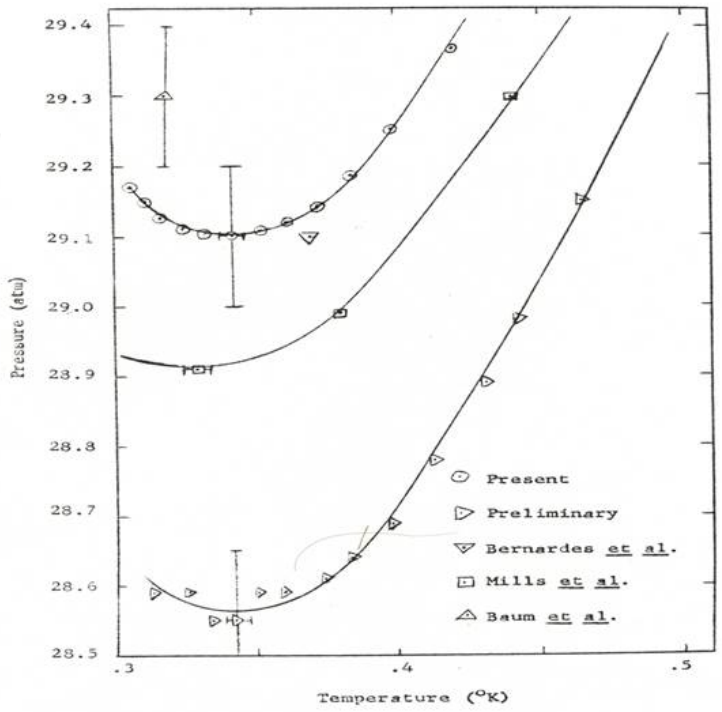


Fig. 4. The Melting Curve Minimum.

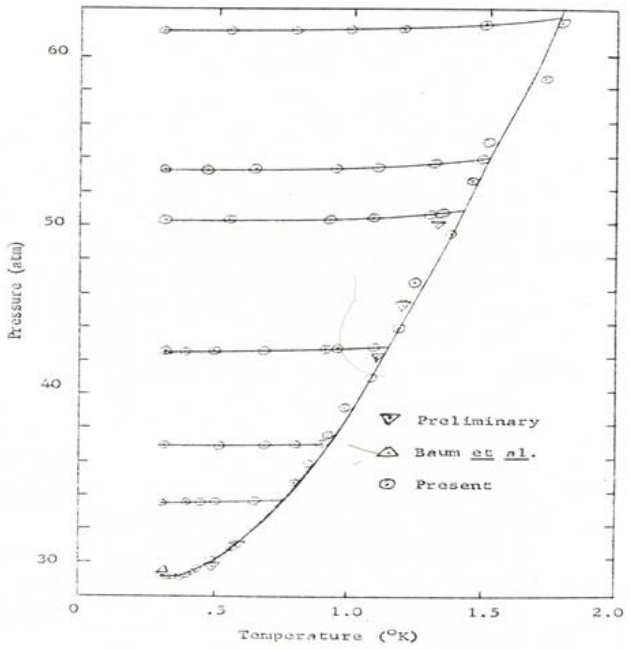


Fig. 5. Composite of the Solid Phase Isochores and the Melting Curve for He^3 From the Present Measurements.

The compressibility is calculated from these curves.

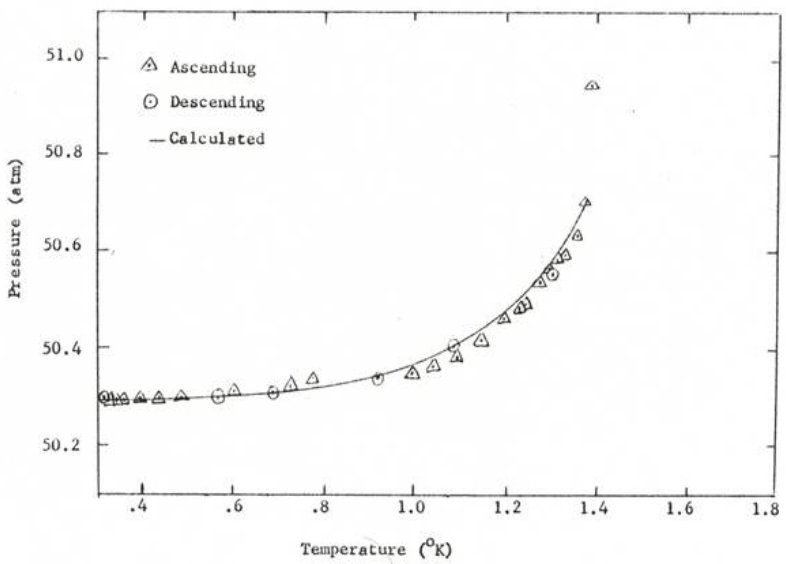


Fig. 9. Pressure vs. Temperature for 22.50 cm^3/mole.

Actually, the pressure vs temperature curve is flatter than show here. The upward volume is due to slippage in the capillary as the sample nears the melting value.

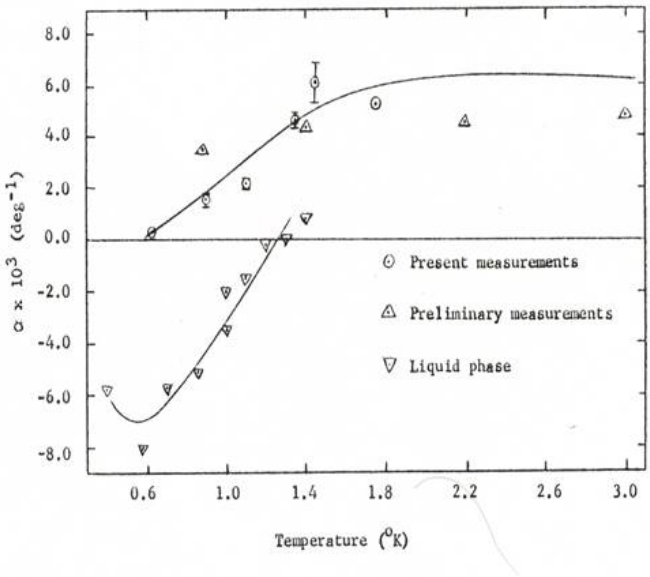


Fig. 14. Thermal Expansion Coefficient of the Liquid and the Solid Phase at the Melting Curve.

In addition to be above, I had made some calculations of the specific heat of solid helium three based on the measured compressibility and thermal expansion data using methodology from Kittel's and Dekker's solid state physics books. I found that it agreed quite well with experiment.
I also made some preliminary measurements of solid helium-4 also.
Neither the specific heat calculation nor the helium-4 measurements were included in my thesis, however, because Dr. Adams felt they were not appropriate for some strange reason.
In any case, of the many fun projects I have had in my career, this was one of the funist. It was a real pleasure to work with Dr. Adams, and was a great learning experience.

* It should be commented that, while we were working on the measurements, a former undergraduate student of Dr. Adams came back in town for a visit. He was, at the time, doing graduate work at Duke. He described a capacitive stain gauge they were working on that used radial expansion rather than linear expansion as we were doing. We said nothing about what we were doing for obvious reasons. But the implication was clear. Had we not started at the time we did, then Duke might have beaten us to the measurements. Obviously, timing is everything!

Comments from the book **Helium-3 and Helium-4**, Wm. E. Keler, Plenujm Pres, 1969 are shown below. My strain gauge seems to have done well! Strangely, however, my name seems to have gotten lost somewhere here.

experimental and theoretical work which appears to provide an appealingly consistent description of the melting phenomena in He^4 below 1°K.

Straty and Adams ([58]) have measured $P_m(T)$ between 0.35 and 0.95°K using for the pressure sensor a capacitive strain gage with a sensitivity of $\sim 10^{-4}$ atm. This is truly a tremendous advance in pressure resolution at very low temperatures. Their results for $P_m(T)$ and $dP_m(T)/dT$ are shown as open circles in Figs. 9.12 and 9.13, respectively (P_{min}, T_{min}) has been placed at (24.96 atm, 0.775°K), with the difference $[P_m^{(0°K)} - P_{min}]$ estimated at only 0.0075 atm. This latter estimate should be fairly reliable, since at the lowest temperatures, $dP_m(T)/dT$ appears to have reached its limiting value of zero as demanded by thermodynamics.

The high quality of these results induced Goldstein and Mills ([59]) to elaborate on their earlier theoretical work ([26,52]) and to attempt a detailed explanation for the melting anomaly. Qualitatively, the minimum in $P_m(T)$ was expected on the basis that phonons are the dominant excitations in the condensed phases at low temperature. In the solid, both transverse and longitudinal phonons are possible, while in the liquid, which cannot support shear, these modes are restricted to

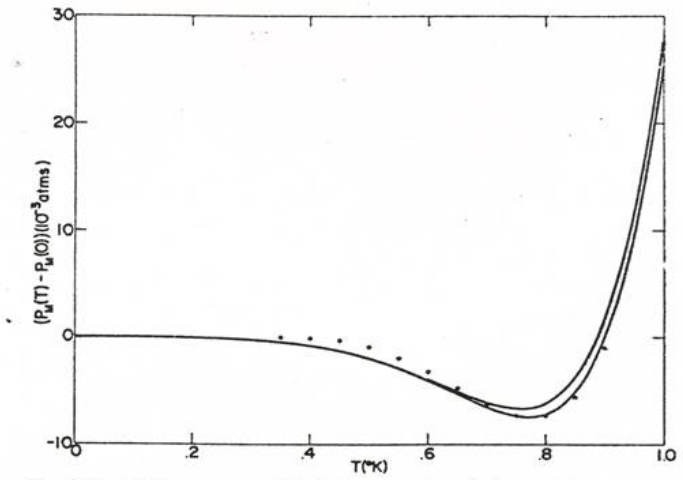
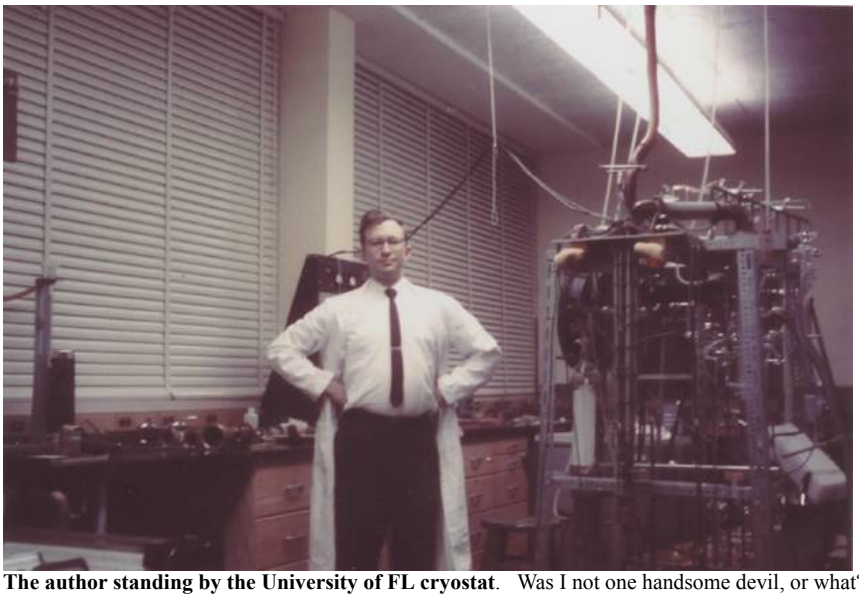


Fig. 9.12. Melting curve of He^4 showing the minimum. Pressures are referenced to P_m at $T = 0$°K. Upper curve calculated from thermodynamic data; lower curve calculated from spectral parameters; data points from smooth curve of Straty and Adams ([58]). [From Goldstein and Mills ([59]).]

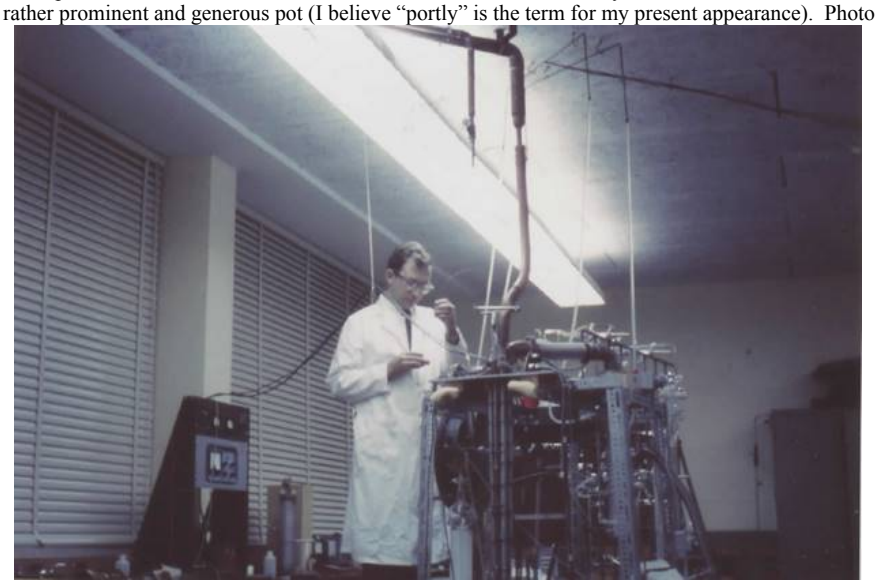
It should be commented that I was Dr. Adams' first graduate student. Gerald Straty, on the other hand, joined the lab about the time I left, some 6 months – 8 months later, and well after I had made these measurements and completed my thesis. I should also note that Dick Scribner joined the lab a month or so after I got there, well before Straty got there, and helped out with some of the measurements because they turned out to be a lot of work. This was because once the cryostat was cooled, you needed to keep moving because the liquid helium, that was used to cool the apparatus, was quite expensive. We had no reclamation equipment, so the evaporated helium was lost. Dick, Dr. Adams and I were working long shifts, and I even slept on a cot in the lab for a short time.
Dick's help, by the way, was most appreciated.
Also, Mike Panczyk joined the lab not long after Dick got there, and sometime later, David Heberlein joined the lab, as I recall, several months after Mike joined.
Both Mike's and Dick's pictures are shown below.
We were Dr. Adams' first four graduate students, and Gerry Straty was the fifth, as I recall.
Apparently, this sensor made it to the Smithsonian, also, but with my name left off. See Appendix 6.

The University of FL Helium-Three Cryostat in the 1964 – 1965 Time Frame

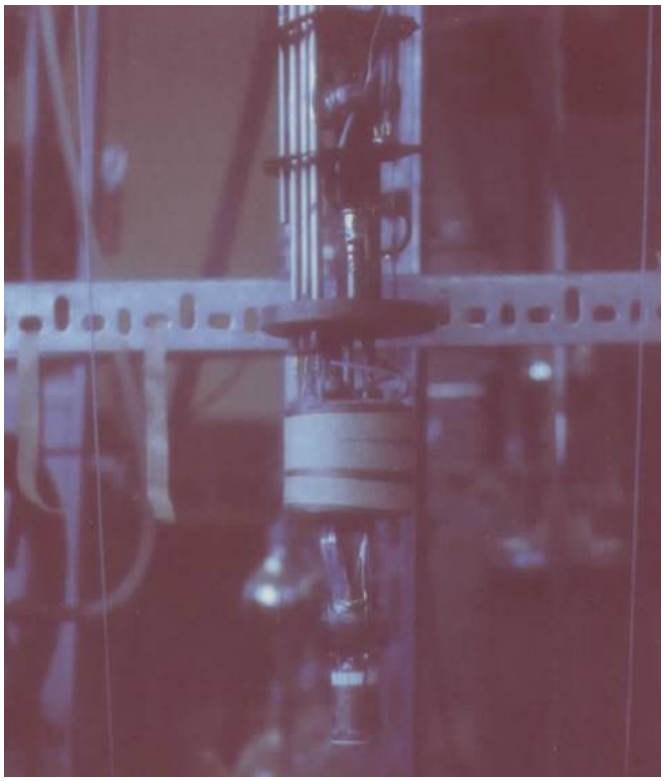
Note: I located the following pictures in a pile of old photos on August 13, 2013, nearly 50 years after they were taken. I had forgotten about their existence.



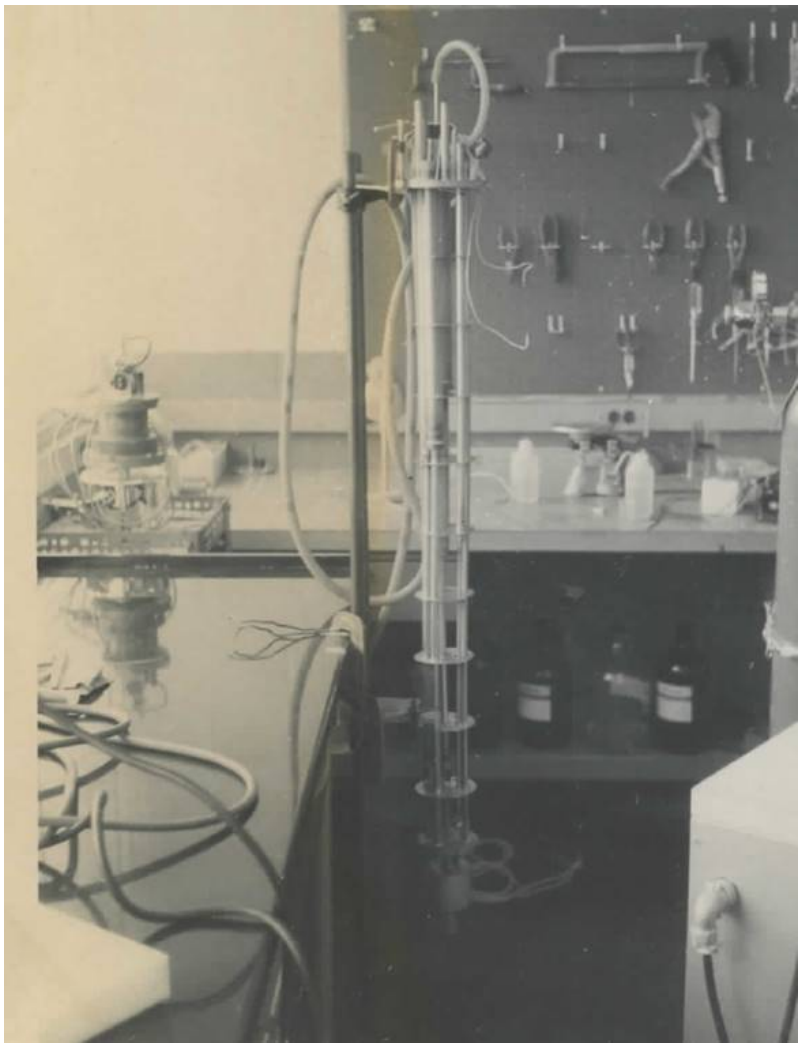
The author standing by the University of FL cryostat. Was I not one handsome devil, or what? Not only that, I had a full head of hair and I had a relatively small pot. These statements are now far, far from true now, almost 50 years later. I am now a wrinkled up old geezer, I don't have much hair, and I now have a rather prominent and generous pot (I believe "portly" is the term for my present appearance). Photo taken by Dick Scribner, as I recall.



Still another picture of the author and the cryostat. The sample chamber hung from the column of straight pipes (hard to see in this dark photo) on the left side of the erector set. A long nitrogen dewar was pulled up around the column of pipes and the test chamber and it was filled with liquid nitrogen during operation.

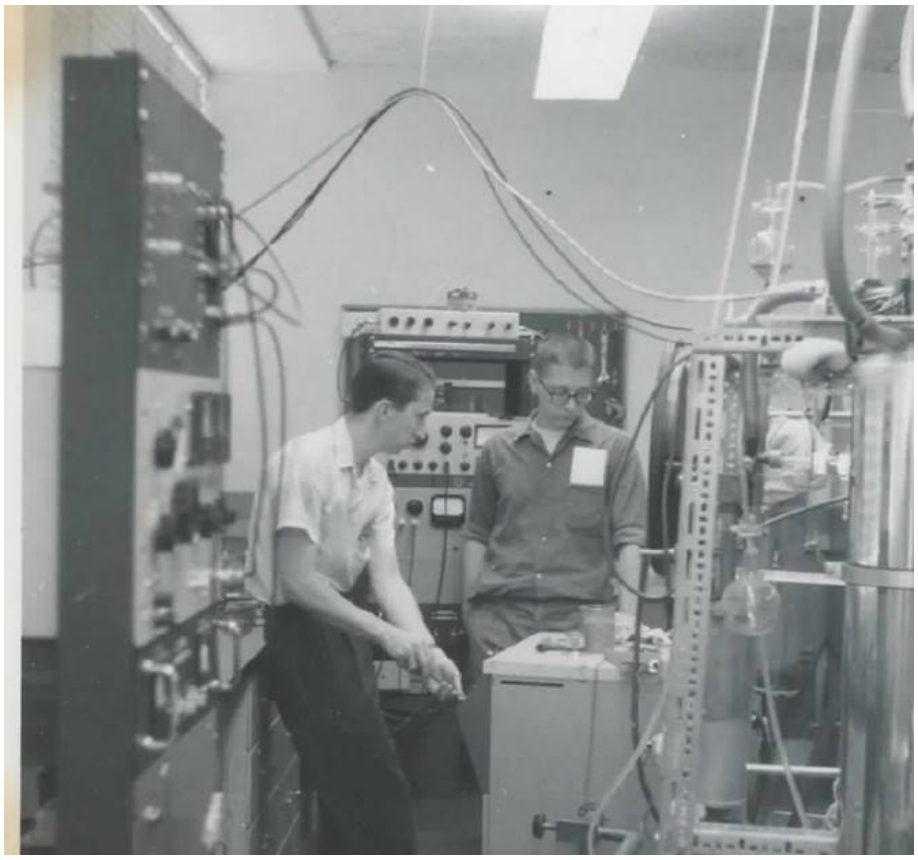


Details of the sample cooling system (Based on a 50 year recall): The large circular chamber just below the cross beam contained liquid helium-four, and when a vacuum was pulled on it, the helium-four boiled, thus cooling itself and the helium-three refrigerator hanging below. When a vacuum is pulled on the helium-three chamber, it boils the helium-three which cools itself and the sample chamber below it even more. The small cylinder at the bottom is the solid helium sample chamber that contains the strain gauge. It is suspended from the helium-three refrigerator, a dark, near invisible entity that terminates several curved tubes in the photo above.
In operation, the refrigerators and sample chamber were sealed in a cylindrical chamber that was bolted to the circular plate above the helium-four refrigerator. This chamber was evacuated, thus insulating the refrigerators and sample chamber from the outside world. That way, their only thermal contact with the outside world was the circular plate, so that after cooling down to the minimum temperature, the temperature of the sample chamber will drift up slowly at a fixed molar volume so the pressure/temperature profile can be observed. (Again, the complete details are a little hazy as this is based on my memory after having not viewed this apparatus, these pictures for nearly 50 years, nor have I even even thought about it since then.)

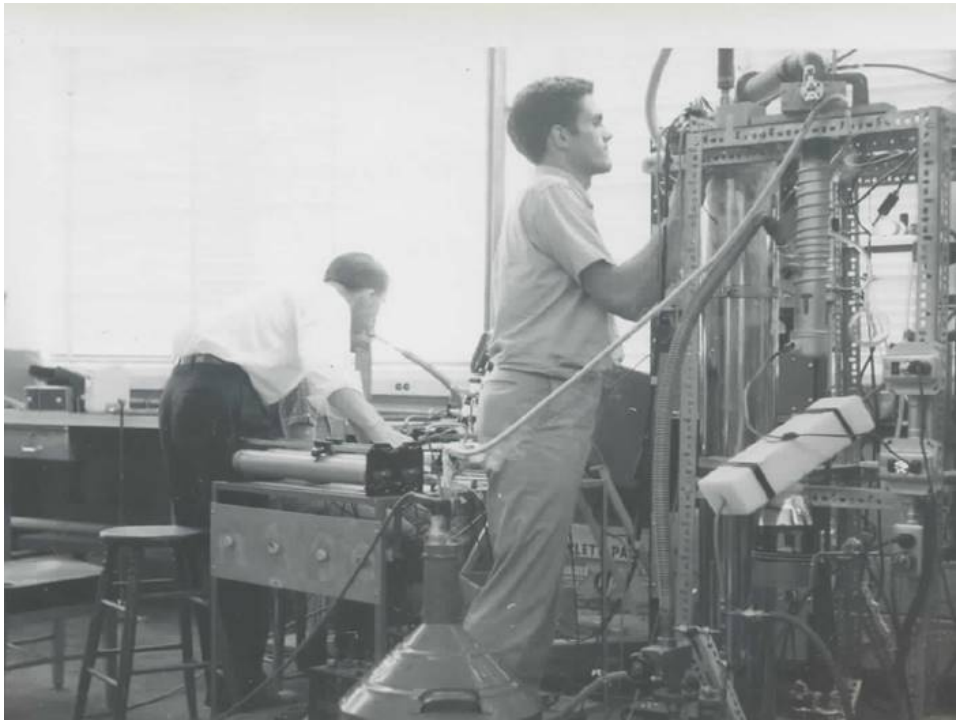


Innards of the cryostat.

Dr. Adams is the man with the rubber hose, and I am working on the cryostat. The graduate student was Ed Garbaty. He was from another lab, as I recall. The picture was likely taken by Dick Scribner.



Dr. Adams and graduate student Mike Panszyk operating a vacuum pumping station, probably evacuating the helium-three glassware.



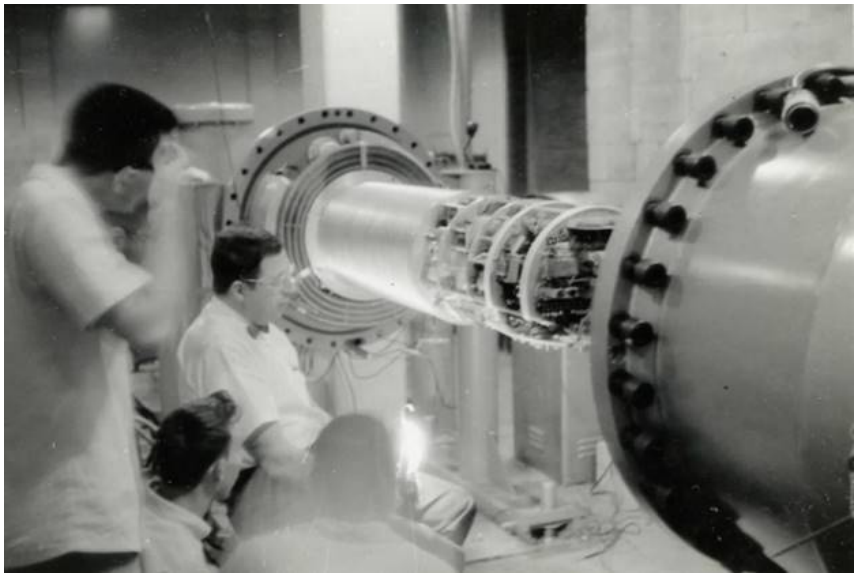
Graduate student Dick Scribner working on the cryostat, Dr. Adams is in the background. I believe we were taking measurements at the time, and Dick's help with the measurement was most helpful and was most appreciated. David Heberlein probably joined not long after these pictures were taken, as I recall.

Note also there are no pictures of Gerald Straty because he had not joined the lab as yet. He joined about the time I left, about 6 – 8 months after I built the first version of the strain gauge, and just before I left.

Mack, the Cryo Tech at the Collins cryostat. The machine liquefied the helium for use by the entire physics department. The square black object by the technicians hand is the expansion engine which is like a little steam engine that turns the flywheel (with the silver rim), the exhaust helium being cooled in the process. The large shiny silver canister in the lower right is a helium Dewar for holding the liquid helium.

© Ernst L Wall 2007, All Rights Reserved

18. Nuclear Physics at the University of GA, 1960



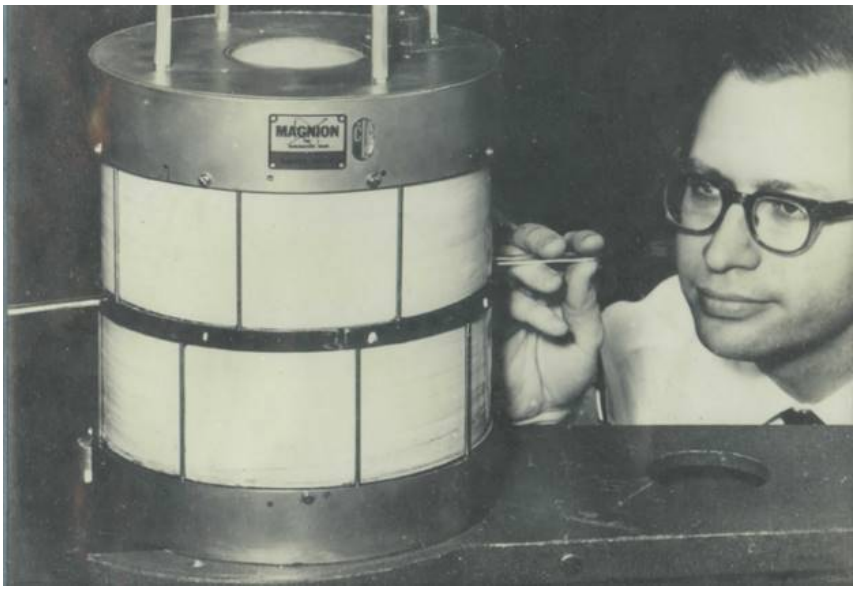
In the late 1950s, particle physics was relatively rare. Most research projects involved low energy nuclear physics. The 2 MeV, state of the art, Van de Graaff accelerator shown here was used for polarized n – p scattering experiments. Recognizable figure is Dr. Lewis Rayburn, the physics department chairman.

I spent several quarters machining hardware and assisting in carrying out experiments with this machine.

The closest I ever had to getting a job involving nuclear physics was to have an interview at Oak Ridge National Laboratories. The job would have involved the thrill and joy of babysitting a calutron that separated U238 and U235. Wow!! However, I never got an offer, thank goodness!!!

---

19. Design Techniques for Large Bore, Split Pair, Superconducting Magnets



The Fort Belvoir Magnet. The Lucite rod shows the path that light would take going through the high homogeneity center field. Room temperature access to the center of the magnet was via a "finger Dewar" that went through the center bore of the magnet.

After I finished my Masters thesis, I decided to take a sabbatical to work at Cryonetics, a cryogenics company in Burlington, MA, with the intent of coming back to FL for a PhD later. The president of the Company was Richard Morse, a physicist who had founded National Research Corp and was the inventor of Minute Maid orange juice. The VP was Dr. Conrad Rauch, to whom I reported.

When I arrived there, the standard technique for winding superconducting magnets was a method designed by Laverick at Argonne National Laboratories. It specified a layer of stainless steel screen between layers of superconducting wire. This allowed the liquid helium to flow in and cool the wire. That was the state of the art method that was universally used at the time.

However, the day before I arrived, Cryonetics' first magnet, a 3 inch bore, 50 kilogauss magnet had been tested and it went from the superconducting state to normal at about 25 kilogauss and it ripped itself apart in a cloud of helium. I.e., it exploded.

Obviously, Laverick's method had a problem. Worse, when you had a split-pair, i.e., two magnets with a gap between them, that was known to exacerbate the problems with reaching high fields. That, by the way, is not meant in any way to disparage the management at Cryonetics, who were obviously an extremely capable bunch. Had I designed that magnet for the first time, I would have used Laverick's method just as they did because that was the standard industrial methodology.

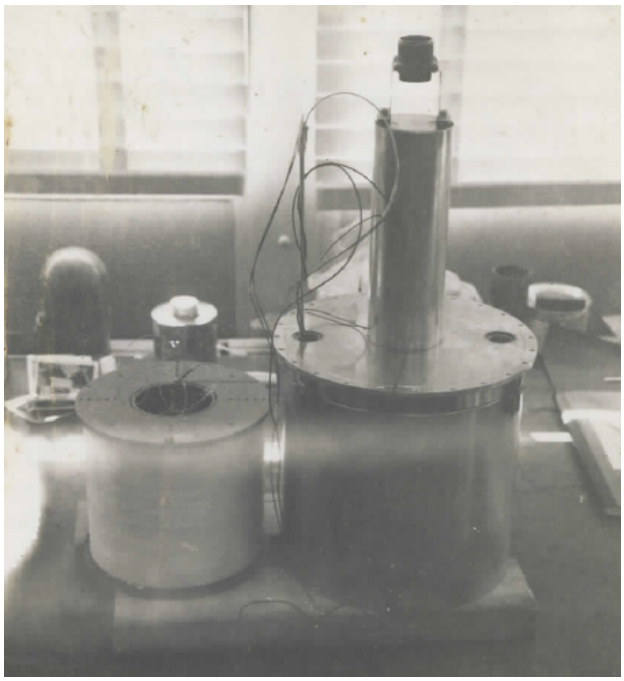
In any case, the problem was assigned to me. That put me in a bit of a pickle because I knew nothing about superconductive and superconducting magnet design. Also, there was no enough money in the till to waste on useless experiments because superconducting wire and liquid helium were very expensive. It had to work the next time, or else.

Hence, I stopped all work on the project and discussed the problem with Dr. Rauch. He theorized that the problem was caused by "flux jumping" wherein localized high magnetic field caused the superconducting wire (Niobium Zirconium) to momentarily go normal, and the localized field would then spread out allowing the wire to go back to the superconducting state. At a high enough current, the I^2R heating could be so extreme as to cause the wire to go into thermal runaway rather than going back to the superconducting state.

After thinking about it, the solution seemed obvious. I had the magnet rewound, but with a layer of OFHC copper sheeting between each layer of wire. The copper sheeting was shorted back on itself and the overlapping ends joined with low temperature solder so as to form a conducting copper sheet between each layer of wire. This way, any localized flux jumps would generate a counter current in the copper that would damp out the jump. Winding it was a very laborious job carried out by our excellent cryotech, Guy Petagna. It should be commented, by the way, that Guy was one of the wittiest, funniest people I ever worked with.

When the magnet was complete, we put it in a Dewar and charged it up. It then easily made the 50 kilogauss specified field. We ran it up in current until it quenched (went normal), but instead of exploding, it seemed to give off what seemed like a very gentle sigh of relief with the liquid helium slowly boiling off. We then wound the second magnet of the pair and put them together into a split pair, but we could only get them up to 45 kilogauss in this configuration.

However, the customer was very content to accept it at that field. Having room temperature access to its large bore via a center tunnel in the Dewar, It was to be used to for beta decay studies by Dr. James Blue of NASA Lewis Research Center. It had a variable spacing between the magnets using a bellows like Dewar section between the Dewar for the upper magnet and a Dewar for the lower magnet.



NASA Lewis magnet partially assembled. The lower magnet is contained in the lower Dewar, and the magnet on the bench on the left will later be placed in a Dewar that goes on top. The two holes in the center plate are where the cryo bellows connect the upper and lower Dewars. The large center bore allows room temperature access to the sample. The spacing between the Dewars could be varied, depending on sample size and desired magnetic field homogeneity.

The second magnet, for Fort Belvoir, was next. (It is shown at the top of this section. I overdesigned it in terms of the amount of wire so as to be sure of meeting the 50 kilogauss spec. When we tested it, we heard metal tools slamming against the door of a nearby metal cabinet as they were attracted to it. Then, we noticed the bottom of the locked door of the cabinet begin to bend outward towards us. However, we could only get it up to 65 kilogauss because of the current limits of our power supply.

We finally made it quench by shaking and kicking the Dewar, and like the first magnet, it quenched by giving a slow, gentle sigh of relief.

The wires, multi stranded Niobium Zirconium, were spliced together by spot welding them together. Because the weld joints will go normal at a reduced field, we put the splices on top of the outer edge of the magnet and shielded them with thin, flat sheets of NbZr.

This later magnet is one shown above. It was meant to be used for the study of optical properties of materials in high magnetic fields. Hence the radial holes in the flat center plate could be used for passing light through the material. We use commercial sapphire windows for passing light through the Dewar. A “finger dewar” allowed the room temperature sample to be placed in the center of the magnet for study.

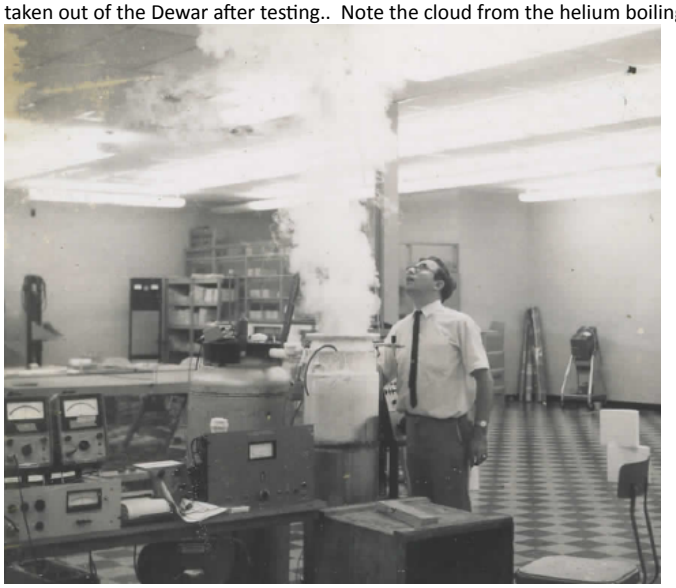
In hindsight, I should have published the methodology because it was, to my knowledge, never done previously. However, I had other issues to deal with at the time, including the fact that Cryonetics went under and was bought out by Magnion.

Also, in hindsight, aside from damping out the flux jumps (which you could hear as a thumping sound in the Dewar), it is likely that the thermal mass of the copper helped prevent thermal runaway, and also, it helped conduct the heat away from the hot spot towards the edge of the magnet.

When the second magnet was shipped, I was canned. That seemed like a disaster because I had just gotten out of the hospital with a serious ailment (metastatic melanoma), but it indirectly led to my hearing about in a job with Transitron, an early semiconductor house in Wakefield, MA. I got the job, and I was now in a new field, and I had 10 incredible years in signal processing before I got canned again. I then taught myself digital design and built a single board computer which I controlled with a teletype. I later wound up in microcomputer design at the ITT Advanced Telecommunications Center. I and later in moved into embedded software, signal processing, and after ITT sold System 12, a 100 thousand line telephone exchange to the French company Alcatel, I became an embedded software contract engineer, as well as a signal processing and algorithm contractor.

The moral of this is: A physics degree can be an incredible ticket to incredibly fun jobs. Also, sometimes getting canned is the case of a door being slammed in your face (even with health issues) only to have a much better door down the hall open before you.

Guy Pegagna standing by a magnet test Dewar. The partially assembled NASA Lewis magnet is on the hoist on the right and is covered with frost because it was just taken out of the Dewar after testing.. Note the cloud from the helium boiling off from the Dewar.



I had likely been testing a magnet here, and the helium is boiling off of the test Dewar. This was obviously a very expensive proposition as we were too small a company to own a helium reclamation system.

© Ernst L Wall 2007, All Rights Reserved

---

20. The Savannah Symphony

(Physics isn't Absolutely Everything!)

I was the second bassoonist for the Savannah Symphony for 2 years, the first year being while I was a senior year in high school, and the second year was during my first year of college at Ga Southern University in my home town of Statesboro. (It was then called Ga. Teacher's College and boasted about 500 students.) During my first year, I made enough money to buy my own G. H. Huller bassoon, an East German make. A Heckle bassoon was far beyond my reach, as much as I would have loved to have had one. In my second year, I made enough to pay for my first year of college plus a little left over for my second year at the University of GA in Athens. I was even a member of the Musicians Union, James C. Petrilo, President.

It almost tore my guts out when I had to resign from the Symphony to go to the University of Ga at Athens. The conductor, Chauncy Kelly, invited me to come back and audition anytime I wanted. That pleased me mightily.

I had taken lessons from the bassoonist for the Longines Symphonette the summer before I got the job. He was a graduate of Julliard and was working in Savannah for the summer, and at the end of the summer he volunteered that he could get me a scholarship at Julliard if I was interested. I then had to choose to be a physicist and do music on the side, or be a musician and do physics on the side. The latter seemed to be quite improbable. But for a pore ol' redneck music freak, the possibility of going to a musican's mecca like Julliard was an opportunity beyond belief! In the end, however, I chose physics. That proved to be a far wiser choice in the end as I did play with several orchestras in the evenings while working. However, some health problems and an attendant long bit of surgery that I had at while at Cryonetics left me too debilitated to play regularly in the evenings.

I am the scrawny little bassoonist on the right, just in front of the first trombonist, Dana King. Dana was my band director at Ga Teachers College. He just loved to put the bell of his trombone right in back of my head and try to blow my ears forward. Also, the slide from the trombone went over my shoulder and I frequently got little drops of slobber from his leaky spit valve on my cloths.

I weighed about 115 pounds soaking wet at this time. I was so skinny that if I walked outside with my shirt off, you could hear the wind whistling through my ribs.

==========

21. Publications by Ernst Wall

1. Ernst L. Wall. Book, **The Physics of Tachyons**, 234 pp., (Hadronic Press, 1995)

2. Ernst L. Wall. "A Study of the Fundamental Origin of the Dimensions of the Bohr Radius of the Hydrogen Atom as Determined by the Quantized Dynamic Electric Field Surrounding a Vortex Model of the Electron." The Hadronic Journal **39**, p. 71, (2016)

3. Ernst L. Wall. "Maintaining the First Bohr Orbit Radius by Photon Suppression", Bulletin on the American Physical Society, 2015 Fall New England Section, **NEF15-2015-000044**.

4. Ernst Wall, **"**The Vortex Electron and the Origin of the Bohr Radius and its Fine Structure Constant, and Pilot Waves", Bulletin of the American Physical Society **60**, New England Section Spring, **B5.00026,** 2015

5. Ernst L. Wall, "A Possible Origin of the Fine Structure Constant", Bulletin of the American Physical Society, **59,** New England Section Fall Meeting, **E2.0005**, 2014.

6. Ernst L. Wall, "Revisiting the Bohr Atom 100 Years Later", Bulletin of the American Physical Society, **N32.00002**, **58**, 2013.

7. Ernst L. Wall. "The Electron's Angular Momentum", Bulletin of the American Physical Society **58, NEF13-2013_000008**, October, 2013 .

8. Ernst L. Wall. "Earth's Atmospheric CO2 Saturated IR Absorption", Bulletin of the American Physical Society, **New England Section Fall Meeting, 2008,** http://meetings.aps.org/Meeting/NEF08/Event/92844.

9. Ernst L. Wall, "A Longitudinal Electrical Impulse Field Neutrino and its Origin in Virtual Quanta of the Tachyonic Electron, Muon, and Pion", Hadronic Journal **24**, p. 207 (2001).

10. Ernst L. Wall, "The Tachyonic Electron's Revolving Light Speed Particle as a Non-Radiating, Bound Photon", Hadronic Journal Supplement **15**, p. 419 (2000).

11. Ernst L. Wall, "A Digital State Machine Simulation of the Universe and the Difficulties of Time Travel", Hadronic Journal Supplement **15**, p. 231 (2000).

12. Ernst L. Wall, "The Fundamental Electrodynamic Origin of Electron de Broglie Waves", Hadronic Journal Supplement **15**, p. 123 (2000).

13. Ernst L. Wall, "Electrodynamics of Revolving Light Speed Particles and A Fundamental Basis for de Broglie Waves", Hadronic Journal Supplement **14,** p. 79 (1999).

14. Ernst L. Wall. "Radial Stability in a Longitudinal Electrical Field Neutrino", Bulletin of the American Physical Society **44**, p. 34 (1999).

15. Ernst L. Wall. "Origin of de Broglie Waves in a Tachyonic Electron Model", Bulletin of the American Physical Society **44**, p. 35 (1999).

16. Ernst L. Wall. "A First Tangible Step in the Quest for Hyperluminal Space Travel", Proceedings of NASA's Breakthrough Propulsion Physics Workshop, **NASA/CP - 1999-208694,** p. 349 (Jan 1999).

17. Ernst L. Wall. "A Longitudinal Electromagnetic Impulse Neutrino Model", Bulletin of the American Physical Society **43**, p. 2163 (1998).

18. Ernst L. Wall. "A Possible Fundamental Origin of the de Broglie Equation", Bulletin of the American Physical Society **43**, p. 2163 (1998).

19. Ernst L. Wall. "Electrodynamics of Revolving Light Speed Particles", Bulletin of the American Physical Society, **43**, p. 1399 (1998) .

20. Ernst L. Wall. "On Pion Resonances and Mesons, Time Cancellation, and Neutral Particles", Hadronic Journal **12**, p. 309 (1989).

21. Ernst L. Wall. "Time Cancellation Hypothesis", Bulletin of the American Physical Society **33**, p. 1076 (1988).

22. Ernst L. Wall. "Charm, Other Resonances, and the Tachyonic Particle Model", Bulletin of the American Physical Society **33**, p. 1076 (1988).

23. Ernst L. Wall. "Unresolved Problems of the Tachyonic Models of the Electron and the Muon", Hadronic Journal **9**, p. 263, (1987).

24. Ernst L. Wall. "On Tachyons and Hadrons", Hadronic Journal **9**, p. 239, 1986.

25. Ernst L. Wall. "Indirect Evidence for the Existence of Tachyons; A Unified Approach to the Pion ® Muon ® Electron Conversion Problem", Hadronic Journal **8**, p. 311 (1985).

26. Ernst L. Wall. "The Role of Tachyons in Electron Spin and Muon Spin", Bulletin of the American Physical Society **30**, p. 729 (1985).

27. Ernst L. Wall. "The Role of Tachyons in Proton Spin", Bulletin of the American Physical Society **30**, p. 729 (1985),

28. Ernst L. Wall. "Hamming Code Error Correction for Microprocessors", Chapter 3, **Microprocessor Applications Handbook**, edited by D. Stout. McGraw-Hill.

29. Ernst L. Wall. "Applying the Hamming Code to Microprocessor - Based Systems", Electronics (McGraw-Hill) **52**, p. 103. (Note that this was the feature (cover) article of this issue.)

30. Ernst L. Wall. "Edge Injection Currents and Their Effects on 1/f Noise in Planar Schottky Diodes", Solid State Electronics **19**, p. 389 .

31. E. D. Adams, G. C. Straty, and E. Wall. "Thermal Expansion Coefficient and Compressibility of Solid Helium-three", Physical Review Letters **15**, p. 549

32. E. D. Adams and E. L. Wall. "Thermal Expansion Coefficient and Compressibility of Solid Helium-three", Bulletin of the American Physical Society **10**, p. 519

33. US PATENT: U. S. Patent 3,800,412 awarded to Walter K. Niblack and Ernst L. Wall, "**Process for Producing Surface-Oriented Devices**", April 2, 1974.

© Ernst L Wall 2007, All Rights Reserved

==========

Appendix 1

The Electron and Fine Structure Constant, the Dirac Model, and other Aspects of the Electron

A1.0. The Classical Electron Radius and Fine Structure Constant: A Few Mysteries are Touched On

The classical electron radius is derived by determining the radius of a sphere whose charge is on the surface and whose radius is such that its integrated electrostatic energy is equal to the mass energy of the electron. Note that this is, in effect, a static energy as opposed to the above dynamic energy given by Eqs. 1-4 and 1-5. It's value is well known to be given by

$$\mathbf{r_{classical} = \frac{e^2}{mc^2} = 2.8179403267\,E-13\ cm.} \qquad (A1\text{-}1)$$

Using the fine structure constant, defined as

$$\mathbf{\alpha = \frac{e^2}{\hbar c} = 7.2973525698\,E-03 = 1/137.035999,} \qquad (A1\text{-}2)$$

and the electron's radius (the reduced Compton wavelength), we may write

$$\mathbf{r_{classical} = \left(\frac{e^2}{\hbar c}\right)(r_e) = \left(\frac{e^2}{\hbar c}\right)\frac{\hbar}{mc} = \frac{e^2}{mc^2}.} \qquad (A1\text{-}3)$$

If we divide the reduced Compton wavelength (the radius of the above Compton wavelength electron) by the classical electron radius, we obtain

$$\mathbf{\frac{re}{r_{classical}} = 137.035999 = 1/\alpha.} \qquad (A1\text{-}4)$$

That is to say, the classical electron radius is much smaller that the radius required for a revolving light speed charge to generate the Bohr magneton, so clearly this is not the true radius of the electron. Furthermore, it should be noted that the classical radius is a static entity as opposed to the above Compton wavelength model, which is a dynamic entity.

Unfortunately, we cannot even speculate at this time as to what the significance of the classical electron radius's fine structure relationship to the reduced Compton radius is at this time.

However, we do state that within this model as we have it here, the total electrodynamic energy of the electron appears to be contained within the reduced Compton radius.

Of course, the classical electron radius is much greater than the 10^{-18} cm radius of the particle as measured by high energy scattering experiments. How does this square with the classical radius? We cannot say at this time. That high energy radius is some 10^5 smaller than the reduced Compton wavelength.

Of course, some might worry about the self energy of the tiny 10^{-18} cm charge. We cannot address that here at this time, other than to note that we have accounted for the *observed* dynamic mass energy of the electron via Eq. 1-4. Any self energy that may be contained in that tiny charge does not appear to have any effect on the observable mass energy of the electron itself.

Also, we note that the first Bohr radius of the hydrogen atom is related to the electron's radius by

$$\mathbf{a_0 = \frac{r_e}{\alpha} = 137.035999074 = r_e.} \qquad (A1\text{-}5)$$

More will be said about this and other fine structure relationships in the Section 8, which covers vortex electron and its interaction inside the Bohr atom.

Finally, note that the Bohr magneton is in error with experiment by an amount of

a = 0.00115965218073, (A1-6)

or about 1 ppt. This is called the anomalous magnetic moment. Schwinger showed that this can be approximated as

$$\mathbf{a \approx \frac{\pi}{2\alpha} = 0.0011614,} \qquad (A1\text{-}7)$$

which differs from the experimental error by about 1 ppm.

The current QED value is calculated to be

a = 0.00115965218178, (A1-8)

which is accurate to 10 significant figures.

However, neither QED nor the Standard Model provides a clue as to the origin of the magnetic moment itself, but yet, its deviation from the experimental value is known with incredible detail. This is indeed a rather strange paradox, i.e., not knowing why it has the magnetic moment it has, but being able to calculate its error with such precision.

In a word, why bother about the error when you don't even understand the source of the magnetic moment in the first place?

Finally, for convenience we may write Eq. 1-3 as

$$\boldsymbol{\mu} = \frac{\mathbf{e}\,\boldsymbol{\lambda}_{\mathbf{C}}}{\mathbf{4\pi}} = \frac{\mathbf{e}\boldsymbol{r}_{\boldsymbol{e}}}{\mathbf{2}}. \qquad (A1\text{-}9)$$

This provides a general expression for the magnetic moment of a light speed charge as a function of radius only that we will use later for other particles. (See Section 15.)

A1.1 The Dirac Zitterbewegung Frequency and its Relation to the Vortex Electron

Messiah states that the Dirac Zitterbewegung frequency is given by [5]

$$\mathbf{f}_{\boldsymbol{Z}} = \frac{\mathbf{2mc^2}}{\mathbf{h}}\ , \qquad (A1\text{-}10)$$

which is twice the frequency of the revolving electron as given by Eq. 1-1, and its amplitude is given by [5]

$$\boldsymbol{a}_{\boldsymbol{z}} = \frac{\hbar}{\mathbf{2mc}}\ . \qquad (A1\text{-}11)$$

Calling $\mathbf{a_Z}$ an amplitude would imply that the projection of the motion of the *electron* over time on a graph would be a sine wave having the frequency and amplitude given in Eqs. a1-10 and a1-11. However, this frequency is half that of $\mathbf{f_e}$ in Eq. 1-1, above, and $\mathbf{a_Z}$ is half the radius of the electron as given by the reduced Compton wavelength in Section 1.2. That is to say, based on Eqs. a1-10 and a1-11, the Zitterbewegung description of the electron is half the size and twice the frequency of the electron itself.

Messiah bases Eqs. 1-21 and 1.22 on the historical interpretation by Erwin Schrodinger of a single energy solution to the Dirac equation that oscillates back and forth between a positive state and a negative state with an energy equal to the difference between the two states [6]. That is to say,

$$\mathbf{E}_{\boldsymbol{Z}} = \mathbf{2mc^2}\ . \qquad (A1\text{-}12)$$

This is all well and good if the electron is a tiny, mysterious, 10^{-18} cm fixed charge that has its mass-energy, angular momentum and a magnetic moment viewed as abstract "characteristics".

However, if Schrodinger's interpretation were correct, then this phenomenological model would be changing back and forth from an electron to a positron with an energy equal to twice the rest mass of the electron. That is, the above electron as described above in Eqs. 1-1 – 1.7 would have to reverse its magnetic field, change its energy from positive to negative, and the change its angular momentum. In a hydrogen atom with a maximum binding energy of only some 13 eV, the electron would be immediately ejected. This, of course, would also be true for any atom, so that physical matter, as we know it, could not exist.

Also, such an electron in a Penning trap would be unstable and likely immediately eject itself from the device if it were ever trapped in the first place. This has not been observed.

Moreover, there is no other evidence of a Zitterbewegung state change or associated photon.

In contrast, however, we claim that the that the large and ponderable, Compton wavelength, vortex electron model described above produces an electron frequency based on a classical phenomenological methodology that produces experimentally verified observables such as energy, a magnetic moment, and possibly an angular momentum, and does so in a manner that is intuitively obvious. Such a model cannot flip back and forth between being a positron and an electron.

Based on the above, we claim that Schrodinger's interpretation is incorrect. We claim that, instead, each of the two states in the Dirac model represents a single, separate, steady state solution, there being a positive energy solution and a negative energy solution, so the two possible energies are

$$\mathbf{E}_{\boldsymbol{e}} = \pm\,\mathbf{mc^2}. \qquad (A1\text{-}13)$$

Hence,

$$\mathbf{f}_{\boldsymbol{Z}} = \frac{\mathbf{mc^2}}{\mathbf{h}}, \qquad (A1\text{-}14)$$

which is half that of the historical Zitterbewegung frequency, so that

$$\mathbf{f}_{\boldsymbol{Z}} = \mathbf{f}_{\boldsymbol{e}}\ . \qquad (A1\text{-}15)$$

This would of necessity require that the amplitude given by Messiah, or the amplitude of the projection of the motion of the revolving charge onto a linear graph over time, is now of necessity equal to the reduced Compton wavelength, or $\mathbf{r_e}$.

That is to say, the vortex model described here is, in fact, consistent with the Dirac model, but only in the case of a single state electron energy state, so that there is no Zitterbewegung oscillation between states.

Beyond the above, we make no comparisons with the full Dirac model or the Pauli spin matrices here at this time because any adequate treatment would be too extensive for the general summary we are exploring here. The interested reader is referred to any one of a myriad of quantum mechanical texts for detailed treatments of these models.

A1. 2. Different States of the Electron's Family of Particles

In addition to the electron, we must at least mention the muon and the pion, both of which convert into lighter particles.

The above development for the electron also holds true for the muon in that its magnetic moment and other characteristics could be derived in the same manner as those of the electron.

On the other hand, the pion is considered by the general particle physics community to be a spin 0 particle. However, we use a revolving charge model of the pion to derive the meson equation of Section 3 that produces the psi mesons to within 4.7% . This a pion's charge revolves in a tiny, 0.18503077 fm. orbit, and the result is that its tiny magnetic moment is equal to that of the deuteron. That is to say, we challenge the notion that the pion has no magnetic moment.

We also challenge it based on the results of the Yukawa-like deuteron model of Section 3.2 that requires the pion to have a small magnetic moment equal the deuteron itself. The results of that model speak for themselves.

In short, we challenge the notion that the pion has no magnetic moment based on the results of the meson calculations and the deuteron model. To quote Galileo, in reference to the Earth revolving around the sun after his appearance before the inquisition, "Nonetheless, still revolves!"

The only question is, how to you represent the pion's spin, the magnetic moment being so tiny? Also, how do you measure the magnetic moment, it being so tiny and possessing such a short lifetime?

Insofar as the relationship of these particles to the electron, both the pion and muon convert into lower energy states. I.e., the heaver pion converts into a lighter muon with a larger orbit, and the muon converts into a still lighter electron with an even larger orbit. In both cases, note that there is no emission of radiation or other particles. There is only a release of kinetic energy with the emission of a neutrino. That is, we have that

$$\boldsymbol{\pi \rightarrow \mu} \text{ , } \qquad \text{(A1-16)}$$

and

$$\boldsymbol{\mu \rightarrow e} \text{ . } \qquad \text{(A1-17)}$$

Also, in about 1 case in 10,000, the pion will convert directly into an electron, or

$$\boldsymbol{\pi \rightarrow e} \text{ . } \qquad \text{(A1-18)}$$

Also, note that we do not use the term "decay" in reference to the conversions of Eqs a1-16 - a1-18. This is because there is no emission of an easily observable particle or photon, outside of a neutrino that serves to carry away the mass energy of the heavier particles during the conversion. This ejection of the neutrino generates kinetic energy in the resultant lepton. (See the longitudinal electric field model of the neutrino of Section 5.)

The point to be made here is that the pion, the muon, and the electron are different states of the same particle with the electron being the stable end state of these particles that does not convert into other states.

Finally, it is to be noted that, as yet, we do not have a model for the Tau lepton, whose mass is 1776.82 MeV. Also, there is no direct measurement of its magnetic moment as yet because it has such a short lifetime, although we do compare it, energy wise, to the other particles in Section 4.

A1.3 What holds the Electron Together?

In the simplest stand-alone case, we could view the electron as a trapped photon based on the mass energy of Eq. 1-4. But what traps it? We would normally expect that, in the absence of a central force, the charge would tend to escape with a loss of the energy. We also note here that an explanation as to why the revolving charge does not radiate its energy away is provided in Section 1. Also, we know from scattering experiments that the charge has a very small, but finite size.

However, the electron's Bohr magneton model, above, was originally derived from a negative mass tachyon model, and therein is another concept of the mechanism holding the charge in its orbit. According to the derivation provided in Section 7, the centripetal force of the revolving negative mass tachyon that is attached to the charge holds it in place. The tachyon, being unable to drop below the speed of light, keeps the charge moving in a circular orbit. In order to understand this, however, it is necessary for the reader to go through that derivation. Note that it both cases, the charge and tachyon are point mass particles in contrast to the mass energy concept of the electron.

The same negative mass tachyon model holds for the muon as well. However, it is not stable, whereas the lighter electron is. We have no explanation for this at this time.

The above derivation of the Bohr magneton in was presented without direct reference to the tachyon model for pedagogical reasons. I.e., it was desired to show how simple this model is right up front.

Insofar as the force holding the charge in a stable orbit (beyond the centripetal force of the negative mass tachyon) is concerned, we speculate that an as yet undeveloped interaction between the light speed charge and the changing electromagnetic field propagated within the orbit. We note that the much smaller pion has a lifetime of about 2.6E-8 sec and the muon has a mean life time of 2.2E-6 sec, but the electron is stable. We speculate that there is a critical size needed to support this possible interaction.

Note also that wave mechanics is not used in the above derivations, although de Broglie wavelengths are used in the negative mass tachyon derivation and in the derivation of the meson model. However, we will derive the origin of the de Broglie wavelength from Compton wavelets, below, that are external to the electron. Therefore, while the above electron model does not use wave mechanics internally, it does provide the basis for wave mechanics externally to the electron's orbit by means of the Compton wavelets surrounding it.

Finally, even if there is a question about what holds the electron together, we can still move ahead and use the model without knowing everything about it. After all, the electron has been modeled since the early 1920s without knowing anything about its structure. All that was known was that it had a magnetic moment and an angular momentum, but it was still modeled by Pauli, Dirac, and others.

For any unresolved issues or questions that might arise with any derivation here or elsewhere on this page, see Section 11 where it is likely that it was considered. But better yet, there should be some excellent thesis or other research material to be derived from clarifying these issues.

A1.4. The Typical Quantum Mechanical Textbook Representation of the Electron's Magnetic Moment.

The typical quantum mechanical representation of the electron is that it is a tiny 10^{-18} cm particle, but that has angular momentum and a magnetic moment whose origin is a mystery. As to the origin of the magnetic moment and angular momentum, the members of the quantum mechanical and particle community haven't a clue.

Along these lines, we may rewrite the Bohr magneton as derived in Eq. 1-3 as

$$\boldsymbol{\mu} = \frac{e\hbar}{2mc} = \frac{e}{mc}\frac{\hbar}{2} = \frac{e}{mc}\mathbf{S}, \qquad \text{(A1-19)}$$

where the electron spin angular momentum, **S**, is defined as

$$\mathbf{S} \equiv \frac{\hbar}{2}, \qquad \text{(A1-20)}$$

and where ratio of the magnetic moment to the angular momentum, or the gyromagnetic ratio, is [7]

$$\gamma = \frac{e}{mc}. \qquad \text{(A1-21)}$$

Eq. 1-30 is a typical definition found in a standard quantum mechanical textbook if cgs units of charge are used. (Many books use SI units, and so leave c out of the denominator.) It provides algebraic values, but no physical rationale, no orbital radius or orbital velocity of the charge.

Another methodology is to write

$$\boldsymbol{\mu} = AI = (\pi r^2)\left(\frac{ev}{2\pi rc}\right) = \frac{1}{2}\frac{erv}{c} = \frac{1}{2}\frac{e}{c}|\mathbf{r} \times \mathbf{v}|. \qquad \text{(A1-22)}$$

Defining the angular momentum as

$$\mathbf{L} = m|\mathbf{r} \times \mathbf{v}|, \qquad \text{(A1-23)}$$

Eq. 1-30 may be written

$$\boldsymbol{\mu} = \frac{e}{2mc}\mathbf{L}. \qquad \text{(A1-24)}$$

In this case, the authors bypass the troublesome orbital radius and velocity using the vector cross product. In doing this, they get the correct algebraic expression for the magnetic moment, but they are unable to provide a physical, or phenomenological origin of the electron's magnetic moment as we do here.

A1.5 The Stern-Gerlach Experiment and the Detection of the Two State Electron Spin

The Stern-Gerlach experiment of 1922 showed that a beam of silver atoms could be separated into two distinct components when passed through a non-uniform magnetic field, leading to what was initially referred to as spatial quantization. Later, it was realized that this was due to the electron's having a magnetic moment, but with an angular momentum of $S = \pm \hbar/2$ as opposed to integral values of $\hbar$ for angular momentum.

There were also spectroscopic line splitting considerations due to the electron's magnetic moment, but we have no room to discuss them here.

A1.6 The Pauli, Dirac, and Schrodinger Equations: What They Do and Do Not Do.

In order to model the two states, Wolfgang Pauli devised his 2 x 2 spin matrices, or matrix operators, in 1925 as an extension of Heisenberg's matrix mechanics. These are [8]

$$\sigma_x = \frac{\hbar}{2}\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, \quad \sigma_y = \frac{\hbar}{2}\begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}, \quad \sigma_z = \frac{\hbar}{2}\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, \qquad \text{(A1-25)}$$

where we include the known electron angular momentum value, $\hbar/2$, directly.

These were very nice for use in carrying out atomic calculations. However, they fail to give a clue as to the physical origin of the magnetic moment of the angular momentum. In fact, it is not even necessary to know the origin of these parameters in order to use these matrices. All you have to know is that they exist and determine what their eigenstates and eigenvalues are.

In 1928, Dirac published his relativistic wave equation which contained the Pauli matrices in his resulting 4x4 matrices. This was an extraordinary result in that the presence of the Pauli matrices as part of its solution meant that it provided electron spin as a part of this solution. However, that did not provide a physical explanation

for the origin of the electron's magnetic moment nor its angular momentum any more that the Pauli matrices did. It should also be mentioned that it predicted the existence of the positron.

Note also that the Dirac equation adds a positive and a negative identity matrix to the above Pauli matrices, so that the set of matrices are now 4 dimensional and can be represented as a quaternion. This results in the effect that a 360 degree rotation in physical space will require a 720 degree rotation in Dirac space. (Walter Niblack is thanked for pointing this out.)

(This author once had a brief stint working on inertial guidance systems, and found that quaternions are essential for resolving gimbal lock issues. Also, they give the math freaks something to have boat loads of fun with insofar as the Dirac model is concerned. In fact, doing a google search on "Dirac quaternion" will bring up quite a number of papers on the subject.)

However, quaternions will not provide a physical origin for the magnetic moment or angular momentum of the electrons. In fact, the more math you slop onto the model, the more the basic physics and real understanding gets buried. That is not to disparage math, however, because it has its place in the search for new ideas. The Dirac and Schrodinger models are prime examples of this. It is just that it is important not to forget the physics.

However, to take it a step further, Schiff takes the linear Dirac equation,

$$(E - c\boldsymbol{\alpha} \cdot \mathbf{p} - \beta mc^2)\psi, \qquad \text{(A1-26)}$$

and adds electromagnetic potentials to it so that we have

$$(E - e\phi - c\boldsymbol{\alpha} \cdot (\mathbf{cp} - e\mathbf{A}) - \beta mc^2)\psi. \qquad \text{(A1-27)}$$

After a bit of manipulation, he provides the equation [9]

$$E'\psi = \left[\frac{1}{2m}\left(\mathbf{p} - \frac{e}{c}\mathbf{A}\right)^2 + e\phi - \frac{e\hbar}{2mc}\boldsymbol{\delta}' \cdot \mathbf{H} + \frac{ie\hbar}{2mc}\boldsymbol{\alpha} \cdot \mathbf{E}\right]\psi, \qquad \text{(A1-28)}$$

where **δ'** is one of the 4 x 4 Dirac matrices.

It will be noted that Eq. 1.18 contains the Bohr magneton that we derived from a physical model in Eq. 1-3, which is the known magnetic moment of the electron to within about 1 ppm. This of course is extraordinary that it produces the correct magnetic moment of the electron in such an abstract manner. But it still does not provide a physical, or phenomenological origin of the electron spin or any clue as to its size. (We make no further comments on this equation here. The interested reader is referred to Schiff's book for details.)

Also, by taking the time derivative of the angular momentum $\mathbf{L_X}$,

$$i\hbar\frac{dL_x}{dt} = L_xH - HL_x = i\hbar c(\alpha_x p_Y - \alpha_Y p_X) \qquad \text{(A1-29)}$$

and the time derivative of $\boldsymbol{\sigma_X}$,

$$i\hbar\frac{d\boldsymbol{\sigma}_x}{dt} = \sigma_xH - H\sigma_x = -2ic(\alpha_x p_Y - \alpha_Y p_X), \qquad \text{(A1-30)}$$

where H is the Dirac Hamiltonian.

Comparing Eqs. 1-42 and 1-43, we have for the total angular momentum

$$\mathbf{L} + \frac{1}{2}\hbar\boldsymbol{\delta}', \qquad \text{(A1-31)}$$

and where

$$\mathbf{S} = \frac{1}{2}\hbar\boldsymbol{\delta}' \qquad \text{(A1-32)}$$

is the spin angular momentum of the electron. This, like the derivation of the Bohr magneton from an abstract model, is utterly remarkable. However, it does not provide even a hint as to the physical cause of the angular momentum as we do in Eq. 1-8. (Note that we only outline the Dirac spin model because we do not have the space here to do otherwise. The interested reader is referred to Schiff's book for further details.)

In short, while the Pauli and Dirac models are an essential part of modern physics and both deal with the effects of electron spin on line spectra, both of them fail to provide a clue as to the *physical* origins of the electron's magnetic moment or angular momentum. However, that has not prevented them from being useful and even vital to atomic and other calculations.

In contrast, we provide a very simple model of the physical origin of the magnetic moment and a probable origin of the angular momentum above in Eqs. 1-1 – 1-8.

Finally, the Schrodinger equation works beautifully for obtaining atomic energy levels, but does not predict any aspect of spin.

A1.7 Some Electron Energy Trivia

Another issue to be noted is that Eq. 1-4 (Section 1) can be written as

$$\mathbf{E = pc.} \qquad \text{(A1-33)}$$

From Eq. 1-7, we can also write two expressions for energy. I.e., we can write

$$\mathbf{E = h\upsilon_e}\ , \qquad \text{(A1-34)}$$

and

$$\mathbf{E = mc^2}\ . \qquad \text{(A1-35)}$$

Hence, *for a Compton wavelength entity exclusively*, we can express its energy using a total of three different parameters, namely, momentum, frequency, and mass.

Algebraically, we can show this by expanding Eq. 1-4 as

$$\mathbf{E = h\upsilon_e\ = h\frac{c}{\lambda_C} = h\frac{mc^2}{h} = mc^2 = (mc)c = pc,} \qquad \text{(A1-36)}$$

where we used Eq. 1-6 for **p**. Hence, we can equate the expressions for the electron's energy using three different parameters. Insofar as the algebra for these three equations together is concerned, this is logically correct, *but only for a Compton wavelength entity*.

Finally, it should be noted that this model might raise issues with the Dirac spinors where a rotation of 360 degrees is required for a sign change as opposed to a rotation of 180 degrees for the above. (Walter Niblack is thanked for pointing this out.) See Section 1.16, below.

A1.8 A Few Historical Spinning Physical Electron Models

Probably the first spinning electron model was proposed by Alfred Lauck Parsons in 1915. It supposedly contained a charge ring that spun at the speed of light. However, this author has no access to any literature that provides details of the model as of this time. However, we would be remiss not to at least mention his name and contribution. He should not be forgotten, but his work seems to have been largely ignored until recently when he got his own Wikipedia page.

Some 10 years later in 1925 Ralph Kroning proposed that the electron was a rotating sphere, and thus it generated a magnetic moment. Pauli ridiculed the idea, and so Kronig did not publish it. Shortly after that, also in 1925, two Dutchmen, Ulenbeck and Goudschmid, came to the same conclusion and published it.

Pauli, however, may have had good reason to reject the idea because it was assumed at that time that the electron's radius was the classical electron radius. However, as can be seen from Eq. 1-17, the classical electron radius is some 137 times smaller than the current reduced Compton radius we use here. Hence, its orbital velocity would have to be some 137 times the speed of light.

Apparently, however, neither of these latter two proposals contained a specific model in terms of charge distribution and dimensions, although it is clear that it's radial dimension would have had to have been somewhere near that of this current model. Specifically, the circulating charge or spherical electron's radius would have to have been of the order of that of the reduced Compton wavelength and at least part of it would have moved at the speed of light.

In 20/20 hindsight, it is somewhat surprising that one of these workers did not try to estimate the size of a spinning particle whose surface moved at or around the speed of light. They might have been surprised at the results, especially after Arthur Compton published his results.

But now, fast forward to the current time, and it turns out that high energy experiments have negated Parsons', Kronig's, and Ulenbeck & Goldschmid's models because the electron's charge has been found to be a near point charge around 10^{-18} cm in diameter with no hint of any other associated structures. (This is in no way to diminish these worker's contribution. What they did at the time was completely logical based on the information they had at that time.)

But then, this in turn, creates a quandary for the modern quantum mechanic and particle physicist. This tiny point particle is too small to generate a magnetic moment by spinning on its own tiny axis. Hence, the fact that it has a magnetic moment and angular momentum appear to be considered to be magical "characteristics".

However, what we have done here is take the best of both worlds in Eqs. 1-1 – 1-11. I.e., we have modeled the modern entity as tiny charge (10E-8 cm.), but we require this tiny charge to revolve in a relatively large orbit at the speed of light and whose radius is the reduced Compton wavelength (3.86E-11 cm). This is more like the dimensions that would have been required for those electron models from the 1920s.

Again, we repeat that the model is not an ad hoc model. The Bohr magneton was originally derived from a negative mass tachyon model. A negative mass tachyon was adopted after having abandoned the imaginary mass model as useless. See Section 7.

A1.9. What we know about the electron, physically.

First of all, we know the value of the charge of the electron. This was determined to within about 1% by Millikan and Fletcher using their famous oil drop experiment in 1909. That, however did not provide the most critical parameter, the mass.

However, 1896, J. J. Thompson and his colleagues had previously measured the charge to mass ration of the electron by measuring the bending of a beam of electrons in a magnetic field. However, they did not know the charge at that time. But with Millikan's measurements, it was now possible to also determine the mass.

As for the magnetic moment, the expression for the Bohr magneton had been derived for the first Bohr orbit by Neils Bohr around 1913. In addition, he found that the orbital angular momentum was quantized in integral values of ħ.

In 1923, as described in Section 1.15, Stern and Gerlach passed a beam of silver atoms through a non-uniform magnetic field and found that rather than having a continuum in the trace on the target plate, there were two discrete lines perpendicular to the magnetic field. Initially, it was generally thought that this indicated spatial quantization.

However, subsequent analyses by Pauli and others showed that the discrete, dual traces shown by Stern-Gerlach was because the electron possessed a magnetic moment equal to the Bohr magneton. It also possessed an angular momentum of ħ/2. Of course, since that time, the magnetic moment of the electron has been measured to an accuracy of around 1 ppb, but that value is in error with the Bohr magneton by about 1ppt.

As for the charge size, starting in the late 1960s, electron-positron colliders began providing cross sections of the electrons at energies of 1.5 GeV. Later, starting in the 1989 time frame, CERN's large electron-positron collided produced even higher energies up to 209 GEV around 2000. All of these energies were high enough to shatter the 0.5 MeV electron so that only the charge was left intact. (We assume, for the moment, that it is the charge until something comes along to indicate otherwise.)

Later measurements indicate that the diameter of the electron is of the order of 10E-18 cm, or less.

Hence, the electron's physical characteristics that have been measured include:

1. Charge
2. Mass
3. Angular momentum
4. Magnetic moment
5. The size of its charge

All parts of our model must be consistent with these values, and this is what we will discuss next.

A1.10. Why we claim that this model is logically correct.

To describe the overall approach we have taken with this model, the intent was to deal with only the nitty-gritty grease and grime of the physical details of the physics of the electron. We did not attempt describe it with any vague mathematical wave models that use probability distributions to describe its behavior. The wave mechanical models can be applied to this physical model at some convenient time in the future so as to check for consistency, but not at this time.

To begin, we will, for the sake of argument, make the (perhaps outrageous) claim that the derivation provided by Eqs. 1-1 – 1-3 is rigorously correct because it provides the expression for the Bohr magneton for the electron. This expression (the Bohr magneton) has been validated by experiment to within 1ppt, and the model does so by using a simple classical methodology in the derivation, and also where the 1 ppt error has been accounted for by QED corrections.

In this model, there are no hidden variables, nor are there any ambiguities in the form of probability distributions. It is totally straightforward and unambiguous.

Hence, we claim Eqs. 1-1 – 1-3 are rigorously correct.

As to wave models, we claim that the de Broglie wave described in Section 1.7 shows that the wave mechanical model likely has its roots in the Compton wavelets.

The mass-energy of Eq. 1-4 is an extension of Eqs. 1-3 – 1-4, and so we claim that it is logically correct and is consistent with observation, and further, is rigorously correct. Equation 1-5 is also reasonably logically consistent, but because of the asymmetric behavior of the Lorenz transformation for macroscopic objects, we are less dogmatic in its validity, but still claim it is not illogical.

The electron's angular momentum described in Eq. 1-8 is known to be the angular momentum of the electron. As we model it here, it is, again, a logical extension of the Eqs. 1-1 – 1.3, so we make the claim that it is logically correct and is consistent with this model, but do so pending a thorough analysis of the internal structure of the electron at some point in the (hopefully) near future.

But to extend this somewhat at this stage, note also that we view Eq. 1-6 as the total momentum of the photon without regard to its distribution across the electron. Internally, the field will be moving at the speed of light as an impulse towards the center of the revolving disk, so that we can have the momentum uniformly distributed across the interior surface of the revolving disk. Hence, the angular moment expression of Eq. 1-8 does not appear to be invalidated at this stage.

However, again, we do acknowledge that more analysis is needed here.

A1.11. The Double Slit Electron Diffraction Experiment

Having established a model back in Section 1 wherein an electron interacts with its own wavelets as they are reflected off of nearby scattering sites, we consider the case of a charge traversing a double slit aperture.

This is shown in Figure 1-1 which illustrates the possible effects of the reflected wavelets on an electron that has just traversed slit B in a double slit diffraction experiment. Note that the relatively slow electron is soon overtaken by the wavelets reflected from the edges of the slits, and with null reflections from the open area of the slits and, in an idealized case, specular reflection elsewhere. (Specular reflection is used rather loosely here, because a surface would, in fact, consist of atoms with some reflection back to the electron.)

Also, it is to be realized that in a real life model that the edges would not be so straight as show here. The edges of the slit would be highly uneven and consist of millions of atoms functioning as scattering centers so that what we would see would be an average of millions of reflected wavelets of all phases interacting with the electron.

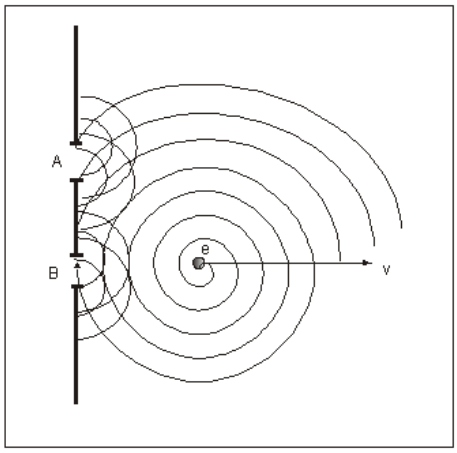


Figure 10-1. A very simplistic illustration of the spiraling field of an electron that has just traversed a slit and the correlated reflections of the Compton wavelets as they reflect off the edges of the slits.

It should be noted that as the electron *approaches* the slits before traversing them it would also be influenced by those wavelets that are reflected off the slits as it approaches. But that is irrelevant here because it has only have two possible paths to take if it is to traverse the slits, either slit A or slit B. The probabilistic interference pattern at some planar screen to the right of this drawing would be determined *only* by the reflected wavelets that are emitted *after* the electron has traversed the slits.

To test this reflection model for the slit, we propose a double slit experiment where two complete slits are photo etched into a thin piece of metal. However, half of one of the slits, say the upper section, should covered by conductive layer on the electron source side of the slits, but displaced from the slit, i.e., a square channel parallel to the slit. That way, the lower half of the slit pair will permit electrons to penetrate both slots while the upper half permits electrons to penetrate only one slit. However the upper section of the slit opposite the source will appear to the exiting electron's wavelets to be open so that the model shown in Fig 4 can be verified. If the reflection model is correct, then there will be little or no difference in the interference pattern on the covered section or the uncovered section of the slits.

(See publications 10, 12, 13, 15, 18, and 19, below)

©☐Ernst L Wall 2007, All Rights Reserved

A1.12. Electron-Lattice Site Scattering of Compton Wavelets - The Davison Germer Effect.

Figure 12 shows an electron moving directly towards a lattice scattering site at some velocity, v, while emitting direct wavelets towards it. Here, we hypothesize that the Compton wavelets of a given electron will be reflected from the lattice atoms, thus forming "interference" patterns. However, there is no constructive or destructive interference as in the case of electromagnetic waves; there are only phase differences between the Compton wavelets. Those regions wherein the wavelets are in phase we will call *Compton ridges*. Those regions wherein they are completely out of phase we will call *Compton channels*. When the ridges impinge on an electron, it will get a slightly greater impulse that in the channels so that it tends to be probabilistically scattered in the direction of the ridges. This is not simply because the wavelets in these directions are all in phase with each other but because they are all in phase with the electron itself and give it a slightly greater probability of being scattered in this preferred direction. See Figure 6, below.

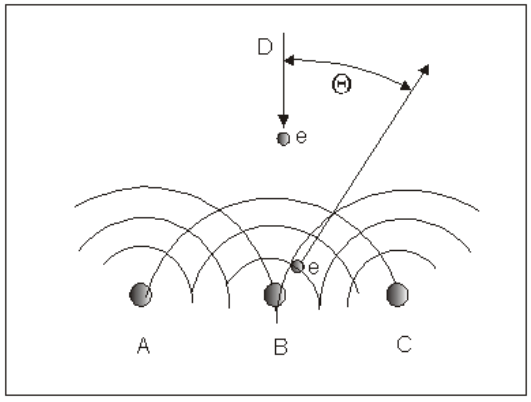


Figure 11-1. Here, an electron approaches a crystal lattice from location D. It is later reflected through an angle q in a probabilistic direction based on the effects of the combined self correlated Compton waveletts reflected from lattice sites A, B, and C. Note that the electron moves relatively slowly while the wavelets move at the the speed of light.

The Davison-Germer experiment was an experiment that succeeded in making the first direct measurements of the effect of de Broglie waves. Published in 1925, it was the first physical evidence for the existence of de Broglie waves. In that experiment, currents of some 10 microamps at 50 – 100 volts from a 1 mm cathode bombarded a nickel crystal and the intensity of their directional dependence followed that calculated by the de Broglie model.

(See publications 1, 21, 23, 25, and 26, below)

©☐Ernst L Wall 2007, All Rights Reserved

==========

Appendix 2

A Digital State Machine Simulation of the Universe and the Difficulties of Time Travel

Ernst L. Wall
The Institute for Basic Research
Palm Harbor, FL 34684
April 26, 2000

Published: Hadronic Journal Supplement **15**, p. 231 (2000).

Abstract.

The flow of time, in previous scientific literature, has been discussed in terms of classical thermodynamics and statistical mechanics. Here, we propose a new approach to the study of time flow by taking advantage of concepts derived from modern computer science. We devise a thought experiment that uses a hypothetical, gigantic digital state machine to simulate the universe. This simulation will, at least in concept, process objects that include atoms, nuclei, particles, and photons. These objects change state on a regular basis at a rate determined by a clock whose period is based on the frequency of a gamma ray. This clock provides a high time resolution so that the total state count, as it progresses from one discrete state to the next most probable discrete state, provides a new definition of absolute time. Absolute time is a count of the all states of the universe from its beginning to any given count. Based on this state machine argument, time travel to some absolute past would require that copies of all past states of the universe be stored in some medium, somewhere, so that the time traveler could rewind the universe. This would seem unlikely with today's technology as well as the technology of the foreseeable future, so that time travel would seem to be an unlikely possibility. Further, we demonstrate that time could not exist without the existence of matter.

1. Introduction.

In many publications in recent years, especially in the popular press, science fiction articles, and even the movies, much has been presented about human beings undertaking reverse time travel that ostensibly occurs as a consequence of such diverse phenomena as traversing wormholes and exceeding the speed of light.

But reverse time is a very real concern today for those who investigate tachyons, or particles whose velocity exceeds the velocity of light. This has been a consideration from the earliest days of the investigations of these particles because of the causality issues, or the assumption that these particles travel backwards in time and cause difficulties with the present(1, 2, 3, 4).

The usual classical thermodynamic counter to the argument for the possibility of reverse time travel, at least for large macroscopic bodies, is to simply state that increasing entropy, the arrow of time, is always in the direction of increasing time, so that reverse time movement is impossible (5).

While a study of time flow using the concept of increasing entropy is not a difficult concept, we will develop a new method that is conceptually even simpler than the entropy argument, but at the same time, it provides a far greater conceptual extent. This methodology easily demonstrates that the phenomena of time travel for a macroscopic body is a highly questionable possibility, at least based on physics as we know it today. This new method is based on a more modern concept, namely, state machines as implemented by modern computer technology.

2. Scope of Investigation

In this work we will describe a method of simulating the universe by means of a hypothetical digital state machine. We will use this state machine model to arrive at a new definition of time, specifically, a definition of absolute universal time. This definition of time will show that matter is necessary for time to exist.

We will use this simulation to demonstrate that to go backwards in time, you would either have to rewind the entire past universe while the future universe continues its forward trajectory, or you would have to have a record of all states of the universe from the present to the point in the past that you wished to visit. We also demonstrate that merely exceeding the speed of light, or transiting a worm hole, does not rewind the universe, nor access hypothetical records of the past. We will use these to demonstrate that time travel is inherently impossible in the physical universe as we know it today.

In this work, we are only interested in introducing a new, basic concept. We are not interested in answering all possible questions that arise from this model. We are not interested advancing computer science, or even in providing an optimum methodology from computer science. We are only interested in a very simple, very basic state machine concept that will illustrate time flow from the standpoint of basic physics. And, it is not necessary to consider relativistic or quantum mechanical aspects of this model in order to introduce it. These would be interesting enhancements of the model, and including them in it would not be extraordinarily difficult. But neither of these are necessary in order to illustrate the basic state machine method of studying the flow of time, and so we will not consider them in this present work.

3. A Simulation of the Universe by Means of a Digital State Machine.

In order to arrive at an improved method of analyzing the difficulties associated with time travel, we describe a hypothetical model of the universe that is a gigantic digital state machine that will simulate the general behavior of the universe as time advances.

State machines are commonly used in the analysis of modern digital logic systems. Not only are they simple to understand, they also provide a more definite methodology for general simulation of statistical phenomena than generalizing from a statistical ensemble. And because a state machine implementation of physical phenomena is generally scaleable, a computer simulation can be implemented at various levels of complexity that range from huge simulations on complex multiprocessor systems to simple simulations in household computers.

This state machine can be sufficiently general as to process a covariant model when it is desired to do so for a large scale, relativistic model of the universe.
This state machine will process a set of objects. Specifically, these objects are particles, including atoms, nuclei, alpha particles, beta particles, electrons and photons, and even tachyons, if desired. Each of these objects has a state that is uniquely determined by parameters that include its mass, cross section, position, velocity, and spin.
We will define the state of the universe at some integral time, t, as

$$S_t = \sum_{i=1}^{N} s_{t,i}\,(m, r, v, k), \qquad (1)$$

where $s_{t,i}$ (m, r, v, k) is the state of some particle i at time t. The state includes mass m, position r, velocity v, and spin k. N is the total number of particles in the universe. Because each particle is in motion, the state of the universe will change from instant to instant. The nature of this change will determine the new state of the particle as it progresses to the next time interval. The new state can be generalized as

$$s_{t+1,i} = \sum_{j=1}^{N} s_{t,i}\; I(s_{t,i}, s_{t,j}). \qquad (2)$$

Here, $I(s_{t,i}, s_{t,j})$ represents an interaction that relates a particular particle, i, at some time, t, to all other particles, j, in the universe. Conceptually, at least, it is inherently symmetric with respect to time reversal because time is merely the sequential progress of the universe from state to state, regardless of whether the state count goes backwards or forwards.

However, digital numbers are inherently limited in precision. As a result, the limited precision of the specification of the targets state could cause motion under time reversal to have a slightly different trajectory than the exact reverse of the trajectory of a preceding, forward state. This provides a built in randomness, of sorts, to $I(s_{t,i}, s_{t,j})$.

But even so, it would still be necessary to provide a time independent random number generator in order to model a more probabilistic trajectory to the next state for each particle, i, as opposed to a definite path. This is because the randomness build into the real universe allows for many possible trajectories into the future. Without this inclusion of randomness, each time the simulation is started from the same point, the forward trajectory would be exactly the same. This randomness must be very small, however.

For a realistic simulation of the universe, the states of all objects, near and far, must all change before a universal state is complete. This is simultaneity of state change. Because of the simulation of simultaneity, the interaction, $I(s_{t,i}, s_{t,j})$, of any two objects must be processed in such a manner as to account for the time of propagation of the interaction from one object to the other. $I(s_{t,i}, s_{t,j})$ is, in fact, an object of simulation in itself.
However, if we wished to simulate a synchronization of distant clocks by means of light signals, then time delays at the macroscopic level would have to be considered as measured by the simulated clocks in the same manner as is used in a typical textbook introduction to special relativity.

4. The Nature of Forward Time Flow

In a digital simulation, the time, t, is an integer value, not a continuous value. Further, the division of time into intervals of seconds is meaningless for this state machine. It is too gross a quantity to calculate the effects of atomic and nuclear transitions because the state of the universe will change millions, or even billions of time in one second. Therefore, a rational calculation of one state based on the previous state is not possible for time divisions or one second or greater. That is, the end state based on such a gross sequence interval is a completely random state with respect to its starting state. What we must have is a time division that is smaller than that of the interval of the fastest changing object in the state set that composes the universe. Therefore, we will define:

The fundamental universal time sequence interval is the minimum time that is required to resolve the state change of the fastest changing object in the set of all objects that constitutes the universe.

In order to implement this definition, we propose that a hypothetical clock having the time sequence interval based on the frequency of a high energy gamma ray be used to separate one nuclear state from the next. In this, we have a mechanical definition of time that is a natural, fundamental state change integer through which the universe can unfold. This fine division of time does increase the difficulties of simultaneity insofar as the sheer size of the model we must process, but we are dealing with a generalized hypothetical model that will deal conceptually with the general passage of time, and this model will be very adequate for that purpose.

But first, we must relate this to the real physical universe. Here, we make simultaneous, hypothetical digital "samples" of the all of the parameters of an object, and store the data in a computer memory. This defines the state of the object. This hypothetical sampling would be done in the same manner as the analog-to-digital sampling that is used in modern day digital signal processing, where we would use the above clock to trigger the samples

Using this, we define a non-subjective, or non-anthropomorphic time as follows:

Absolute universal time is the total count of the state transitions that occur, starting at some initial time of t = 0 at the beginning of the universe and continuing forward to any specified time. These state counts occur when the universe makes regular transitions from one discrete state to the next discrete state.[1]

This definition is not dependent on an anthropomorphic definition of time as derived from earth based intervals. There are no years, days, seconds, etc. It is based only on the requirements that the simulation provide for the most probable trajectory of one state of the universe to the next state based on the behavior of the smallest, fastest objects in the universe.

It is to be noted that in the definition, we specified the "next discrete state" of the universe. But it is important to note that it is also the "next most probable state" of the universe. If our hypothetical computer were used to implement Eq. 2 with the intent of simulating the real universe, then the simulation would calculate each object's new state based on its current state and $I(s_{t,i} , s_{t,j})$, which provides for the most probable next state, not a predetermined, definite state. It is because of the slightly probabilistic nature of $I(s_{t,i} , s_{t,j})$ that the future in the simulation is not absolutely ordained in advance.

Based on the definition of absolute universal time, it is obvious that without physical matter, time has no states to count. And with no state count, there is no passage of time. Therefore, we state that:

The timeless, eternal void hypothesis: In the absence of matter , there are no state transitions to count. Without a state count, there can be no time. Therefore, in the absence of matter, time is devoid of any meaning, and hence, is nonexistent.

5. Reverse Time Flow

Suppose we were to reverse the clock in the simulation and begin processing the state machine in reverse. Starting from the last state that occurred during positively advancing time, the objects would begin to retrace their previous trajectories. However, the randomness that is built into $I(s_{t,i} , s_{t,j})$ would cause them to follow trajectories that are slightly different from their original trajectories. The reverse path would be random, and entropy would continue to increase, just as it did while time was moving forward. However, time reversal would also imply velocity reversal, which would have the effect of reversing the velocity of the objects.

But this velocity includes the not only the velocity of the individual objects, but the composite velocities of all objects composing a macroscopic body. As a result, this macroscopic body would also reverse its velocity, providing that the precision of the digital state specification is sufficient to include the large particle velocities and the slower velocities of the macroscopic objects that are composed of these particles.

While there might be a trajectory to an approximate near past point, there would be no trajectory to any previous, but distant, exact point in the past. As time advances in reverse, the effect on the universe would, in time, behave similarly to the forward movement of time in that the same random state changes and movement of events would be the same as if clock had been counting forward.

For example, suppose we simulate a billiard game. The balls are racked on the table into a triangle, the triangle is broken, and the balls scatter randomly on the table. Several shots latter, we reverse the simulation. Because of the time independent, very small randomness built into I, the balls will not go back to their exact original triangular, racked condition. Disorder, or entropy, has increased.

Similarly, we could simulate the process of adding a drop of milk to a container of water. After a few minutes, the milk will be dispersed. If we reverse the simulation, the randomness built into I will not permit the milk molecules to re-coalesce into the spatially bound drop of pure milk that they started out as.

What is more difficult to predict is the effect of simulated humans and their free will on the progress of reverse time. We will not cover this subject in this work.

6. Tachyons and Time Travel

As previously noted, a tachyon is a particle whose velocity exceeds the speed of light, and in the literature of the past, it it has generally been assumed to travel backwards in time(1). This is another object whose effects are suitable for a very simple simulation within the hypothetical universe.

We make no assumptions about the characteristics of a tachyon, only that it has a velocity greater than the speed of light, and that it has the ability to interact with a subliminal particle. (To date, there has been no direct detection of a tachyon, although indirect evidence for their existence has been proposed (2, 3).)

In a simulation involving a tachyon, two interacting particles, A and B, might have tachyons that serve to carry information back and forth between them. While it would be true that the tachyons would carry information faster than photons, particles A and B still exist in their environment in the present state, not the past or the future. If a tachyon and a photon were simultaneously emitted from particle A and both of them travel toward particle B, the tachyon would scatter B before the photon was able to reach it. This is not to say that there is a causality violation. The tachyon merely beat the photon to the target. Only if an observer at A were attempting to measure a characteristic of particle B by using a photon based signal would there be any reason for an uninformed observer at A to question whether or not causality was violated. This would be a measurement problem, not an actual case of time reversal.

Further, the trajectories of the particles A and B would still progress in a near random fashion before and after the collisions. The presence of the tachyon would merely serve as a different signaling mechanism. A more mundane analogy would be the use of optical observation of an object that was simultaneously being observed by a sonar scan. The light does not present a causality issue with regards to the sonar scan.

In a simulation, a tachyon, even though its velocity exceeds the velocity of light, will not go backwards in time. Neither will the two particles, A and B, above, backwards in time.

7. The Plight of a Would Be Time Traveler

Next, consider the spatial extent of the present day universe, and an individual who wishes to return to some point in the rather gigantic past. If we were travel to some time and location in the past, and if he has the means and the desire to move about the galaxy to any random point, then the entire galaxy must be available to him. That would constitute true time travel. Or, if his means of transport is to be limited, at least he should be able to use a high powered telescope and be able to view the entire galaxy as it existed back at that time. (But even that reduced capability in a real universe would still be a rather substantial achievement.)

There would be two hypothetical options available to the traveler. He could try to rewind the universe itself, or he could try to find a record of the past history and use that to recreate a point in the past.

The probable past would be different from the absolute recorded past because of randomness built into $I(s_{t,i} , s_{t,j})$. In fact, as already stated, the mere attempt to run the universe in reverse would produce, after a short interval of counts, a different past that the actual past. In fact, after a time, the randomness of the rewind of

the universe would make it difficult to say that time was really reversed. It is more likely that after a short time of disorientation, the residents of the reverse universe would begin to carry on as if nothing had happened. They would continue to age, have children, and do their jobs.

To simulate our traveler's visit to an exact point in the past, he must stop the entire universe and then rewind a record it for some specified number of state counts. This requires that a copy of the entire universe for all the past times must be saved somewhere, somehow [2]. That is, it requires that all previous absolute recorded states of the entire physical universe must be recorded. We specify the need to use absolute, recorded states to visit the real past because he does not wish to revisit a mere probable past.

Having reached some point in the past, if our traveler is to move forward from that past point to exactly where he came from in the present, not only must he not cause any influence on the past, he must travel forward in a recorded time sequence, or he will arrive at a substantially different point than that which he departed from because of the random nature of the state change. That is, if the recorded sequence is not allowed to replay, and the universe begins its progress forward in a random manner, then he will progress forward to a present that might be quite different than the one he departed from. This is especially true if he interferes with some critical event in the past.
Further, while the traveler is rewinding the past, the universe must continue to move forward from the point in the present time from which he departs on his journey, and the events of this unfolding reverse state sequence must also be recorded if further visits are to be made to correct any problems that a "previous" traveler may have caused. Further, a new recording of the universe must be made after the present point is reached in order to account for the changes that he caused going forwards from the past, as well as the future point from his departure point.

It could be argued that if a time traveler has only a limited part of space available in a simulation, then he might be able to regenerate a small spatial part of the universe at a particular past time, and then let it move forward in time. This would be a localized time journey. But what would happen if he moved to the edge of this localized spatial environment? What would happen to past residents of this region whose paths crossed over the borders of this region? Would they step into another universe, or vanish? What would that do the future of that local region? These might present severe difficulties for the traveler as well as the previous occupants of the time-spatial region near his trajectory. Obviously the future of this local region might be severely disturbed during the return trip to the traveler's original point of departure, especially on both sides of its borders.

But to complicate matters further, suppose there were multiple time travelers who start out on their journeys at the same time but from different locations. We must ask, which time traveler gets to rewind the universe first? Or, which one gets to go to which copy of which part of the universe at what time?
This problem can become even more complicated if one time traveler has rewound the past universe and moved backwards in time, and is followed some time later by another time traveler who begins to unwind this past universe. We must ask what happens to the previous time traveler in his rewound past universe, and what happens as he returns to the time from which he started his journey.

It is to be noted that we have utilized the term "rewinding" the universal record as an analog to a rewinding a VCR tape or a binary tape from a computer. This is because it is a closer analog to running the universe in reverse. But in these times of random access computer storage, our simulated time traveler could pick a point in the past and return there immediately.

But the simulation of traversing a black hole and jumping back to some time in the past could be done by, essentially, accessing a random point in a mass storage system. This would be an example of near immediate access to a specific point in the past that involved no rewind.

As a brief aside, it is to be noted that as time progresses forward in the recorded universe, the residents have no free will. The traveler, assumedly would have free will, but this depends on the simulation. In any case, it is suggested that some interesting philosophical points could be raised from this issue of free will versus predestination.
These are some of the questions that are more clearly enunciated by the use of a digital state machine simulation than we could obtain from a continuous time, statistical ensemble model of the universe. A continuous time model (i.e., an analog model) that is developed from a statistical mechanical ensemble has no definite transition from one particle state to another particle state (6). An analog recording of the state of a universe and the interaction of its components, or a recording of even a small ensemble of objects, is rather difficult to envision. Therefore, the classical analog model does not permit a hypothetical storage methodology that will permit the concept of storing and rewinding the universe that is as conceptually simple as that obtained from the digital model. The illustrative capability of the analog model is severely limited as compared to a digital state machine.

8. A Digression On Macroscopic Bodies at Hyperluminal Velocities

To depart somewhat from a pure state machine argument for a moment, we will consider a more general discussion of the argument that an object that moves faster than the speed of light would experience time reversal(1,4). For example, the space ship Enterprise, in moving away from Earth at hyperluminal velocities, would overtake the light that was emitted by events that occurred while it was still on the earth. It would then see the events unfold in reverse time order as it progressed on its path. This phenomena would be, in effect, a review of the record of a portion of the Earth=s history in the same manner that one views a sequence of events on a VCR as the tape is run backwards. But this does not mean that the hyperluminal spacecraft or the universe is actually going backwards in time anymore than a viewer watching the VCR running in reverse is moving backwards in time.

Further, it must be asked what would happen to the universe itself under these circumstances. To illustrate this, suppose a colony were established on Neptune. Knowing the distance to Neptune, it would be trivial, even with today's technology, to synchronize the clocks on Earth and Neptune so that they kept the same absolute time to within microseconds or better. Next, suppose that the Enterprise left Earth at a hyperluminal velocity for a trip to Neptune. When the crew and passengers of the Enterprise arrive at Neptune, say 3 minutes later in Earth time, it is unlikely that the clocks on Neptune would be particularly awed or even impressed by the arrival of the travelers. When the Enterprise arrives at Neptune, it would get there 3 minutes later in terms of the time as measured on both Neptune and Earth, regardless of how long its internal clocks indicated that the trip was. Neither the Enterprise nor its passengers would have moved backwards in time as measured on earth or Neptune.

The hands of a clock inside the Enterprise, as simulated by a state machine, would not be compelled to reverse themselves just because it is moving at a hyperluminal velocity. This is because the universal state machine is still increasing its time count, not reversing it. Nor would any molecule that is not in, or near the trajectory of the space ship, be affected insofar as time is concerned, provided it does not actually collide with the space ship.

In the scheme above, reverse time travel will not occur merely because an object is traveling at hyperluminal velocities. Depending on the details of the simulation, hyperluminal travel may cause the local time sequencing to slow down, but a simulated, aging movie queen who is traveling in a hyperluminal spacecraft will not regain her lost youth. Simulated infants will not reenter their mother's wombs. Simulated dinosaurs will not be made to reappear. A simulated hyperluminal spacecraft cannot go back in time retrieve objects and bring them back to the present. Nor would any of the objects in the real universe go backward in time as a result of the passage of the hyperluminal spacecraft.

The mere hyperluminal transmission of information or signals from point to point, nor objects traveling at hyperluminal velocities from point to point, does not cause a change in the direction of the time count at the point of departure nor at the point of arrival of these hyperluminal entities, nor at any point in between.

9. Conclusion.

Based on concepts derived from modern computer science, we have developed a new method of studying the flow of time. It is different from the classical statistical mechanical method of viewing continuous time flow in that we have described a hypothetical simulation of the universe by means of a gigantic digital state machine implemented in a gigantic computer. This machine has the capability of mirroring the general non-deterministic, microscopic behavior of the real universe

Based on these concepts, we have developed a new definition of absolute time as a measure of the count of discrete states of the universe that occurred from the beginning of the universe to some later time that might be under consideration. In the real universe, we would use a high energy gamma ray as a clock to time the states, these states being determined by regular measurements of an object's parameters by analog-to-digital samples taken at the clock frequency.

And based on this definition of time, it is clear that, without the physical universe to regularly change state, time has no meaning whatsoever. That is, matter in the physical universe is necessary for time to exist. In empty space, or an eternal void, time would have utterly no meaning

This definition of time and its use in the simulation has permitted us to explore the nature of time flow in a statistical, non-determinate universe. This exploration included a consideration of the possibility of reverse time travel. But by using the concept of a digital state machine as the basis of a thought experiment, we show clearly that to move backward in time, you would have to reverse the state count on the universal clock, which would have the effect of reversing the velocity of the objects. But this velocity includes the not only the velocity of the individual objects, but the composite velocities of all objects composing a macroscopic body. As a result, this macroscopic body would also reverse its velocity, providing the state was specified with sufficient precision.

But if you merely counted backward and obtained a reversal of motion, at best you could only move back to some probable past because of the indeterminate nature of the process. You could not go back to some exact point in the past that is exactly the way it was. In fact, after a short time, the process would be come so random that there would be no real visit to the past. A traveler would be unable to determine if he was going back in time, or forward in time. Entropy would continue to increase.
But doing even this in the real universe, of course, would present a problem because you would need naturally occurring, synchronized, discrete states (outside of quantized states, which are random and not universally synchronized). You would need to be able to control a universal clock that counts these transitions, and further, cause it to go back to previous states simultaneously over the entire universe. Modern physics has not found evidence of naturally occurring universal synchronized states, nor such an object as a naturally occurring clock that controls them. And even if the clock were found, causing the clock to reverse the state transition sequence would be rather difficult.

Without these capabilities, it would seem impossible to envision time reversal by means of rewinding the universe. This would not seem to be a possibility even in a microscopic portion of the universe, let alone time reversal over the entire universe.

But aside from those difficulties, if you wished to go back to an exact point in the past, the randomness of time travel by rewind requires need an alternative to rewinding the universe. This is true for the simulated universe, and a hypothetical rewind of the real universe. Therefore, the only way to visit an exact point in the past is to have a record of the entire past set of all states of the universe, from the point in the past that you wish to visit onward to the present. This record must be stored somewhere, and a means of accessing this record, visiting it, becoming assimilated in it, and then allowing time to move forward from there must be available. And, while all of this is happening in the past, the traveler's departure point at the present state count, or time, must mover forward in time while the traveler takes his journey.
Even jumping back in time because of a wormhole transit would require that a record of the past be stored somewhere. And, of course, the wormhole would need the technology to access these records, to place the traveler into the record and then to allow him to be assimilated there. This would seem to be a rather difficult problem.
This then, is the problem with time travel to an exact point in the past in the real universe. Where would the records be stored? How would you access them in order just to read them? And even more difficult, how would you be able to enter this record of the universe, become assimilated into this time period, and then and have your body begin to move forward in time. At a very minimum our time traveler would have to have answers to these questions.

Still another conundrum is how the copy of the past universe would merge with the real universe at the traveler's point of departure. And then, if he had caused any changes that affected his departure point, they would have to be incorporated into that part of the universal record that is the future from his point of departure, and these changes would then have to be propagated forward to the real universe itself and incorporated into it. This is assuming that the record is separate from the universe itself.
But if this hypothetical record of the universe were part of the universe itself, or even the universe itself, then that would imply that all states of the entire universe, past, present, and future, exist in that record. This would further imply that we, as macroscopic objects in the universe, have no free will and are merely stepped along from state to state, and are condemned to carry out actions that we have no control over whatsoever.

In such a universe, if our traveler had access to the record, he might be able to travel in time. But he were to be able to alter the record and affect the subsequent flow of time, he would have to have free will, which would seem to contradict the condition described above. We obviously would be presented with endless recursive sequences that defy rationality in all of the above.

This is all interesting philosophy, but it seems to be improbable physics.

Therefore, in a real universe, and based on our present knowledge of physics, it would seem that time travel is highly unlikely, if not downright impossible.
We do not deny the usefulness of time reversal as a mathematical artifact in the calculation of subatomic particle phenomena(7). However, it does not seem possible even for particles to actually go backwards in time and influence the past and cause consequential changes to the present.
Further, there is no reason to believe that exceeding the speed of light would cause time reversal in either an individual particle or in a macroscopic body. Therefore, any objections to tachyon models that are based merely on causality considerations have little merit.

For the sake of completeness, it should be commented that the construction of a computer that would accomplish the above feats exactly would require that the computer itself be part of the state machine. This could add some rather interesting problems in recursion that should be of interest to computer scientists. And, it is obvious that the construction of such a machine would be rather substantial boon to the semiconductor industry.
We already know from classical statistical mechanics that increasing entropy dictates that the arrow of time can only move in the forward direction (5). We have not only reaffirmed this principle here, but have gone considerably beyond it. These concepts would be extremely difficult, if not impossible, to develop with an analog,

or continuous statistical mechanical model of the universe.

We have defined time on the basis of a state count based on the fastest changing object in the universe. But it is interesting to note that modern day time is based on photons from atomic transitions, and is no longer based on the motion of the earth. Conceptually, however, it is still an extension of earth based time.

But finally, history is filled with instances of individuals who have stated that various phenomena are impossible, only later to be proven wrong, and even ridiculous. Most of the technology that we take for granted today would have been thought to be impossible several hundred years ago, and some of it would have been thought impossible only decades ago. Therefore, it is emphasized here that we do not say that time travel is absolutely impossible. We will merely take a rather weak stance on the matter and simply say that, based on physics as we know it today, there are some substantial difficulties that must be overcome before time travel becomes a reality.

References:
1. G. Feinberg, Phys. Rev. 159, 1089 (1967).
2. Ernst L. Wall, Hadronic Journal 8, 311 (1985).
3. Ernst L. Wall, The Physics of Tachyons., (Hadronic Press, 1995).
4. P. Davies, About Time, p. 234 (Simon & Schustere, 1995)
5. P. Davies, op. cit. p. 196.
6. K. Huang, Statistical Mechanics, p. 156 (John Wiley & Sons, 1963).
7. E. Condon & H. Odishaw, Encyclopedia of Physics, p. 9-139 (McGraw-Hill, 1967).

---

[1] **Webster's New Collegiate Dictionary** (1976, G & C Merriam Co) provides multiple definitions of time. The closest definition to what we propose here is "the measured or measurable period during which an action, process or condition exists or continues." It then defines period as "a portion of time determined by some recurring phenomena". This is, of course, circular reasoning. It also provides another definition wherein time is "a continuum which lacks spatial dimensions and in which events succeed one another from past through present to future. This is somewhat of a weak definition compared to what we introduce here.

[2] On a philosophical note, it is of interest to note that in Hindu cosmology every thought, word, and action that occurs in the universe is stored in the Akashic, or heavenly records. (I.e., the ethers, whatever the ethers are). It is unlikely that most Hindu mystics believe that time travel is possible: only that it is possible to read the records. However, some of them do profess to be able to see a *probable* future. But having mentioned this as a fragment of distantly related philosophy, it is emphasized that we do not intend to resort to mysticism or pseudo science in this investigation.

© Ernst L Wall 2007, All Rights Reserved

Appendix 3

"What Waves When You Have de Broglie Waves?"

(A Question Better Left Unasked by Physics Students Before this Current de Broglie Model Came Out)

Question: Who is this?

Answer:

Only minutes before this snapshot was taken he was a healthy, mid 20s graduate student at the University of FL. He made the mistake of asking a quantum mechanic, "What waves when you have de Broglie waves?", without wearing blast proof clothing. He was instantly desiccated by the blast of hot air fanned on by the wildly waving hands of the quantum mechanic.

(No flys on the quantum mechanic, another graduate student, he was just using the standard line regarding this troublesome question that has probably been asked millions of times.)

But not to worry, there was a happy ending! He was left under a large tree in the Florida humidity (covered with a less-than-clean table cloth from the U of FL President's private dining area to protect him from the residue of the very large birds that roosted in the tree), and he was reconstituted by the humidity. Thus it was that, after three days and three nights, he arose and went forth unto class.

Later, when asked if he finally understood what waved when you have de Broglie waves, he answered dryly "Yes! The quantum mechanic's hands!!".

The straightforward explanation of de Broglie waves provided in this web site should prove to be a totally dry but non desiccating. Furthermore, no wildly waving hands are required.

==========

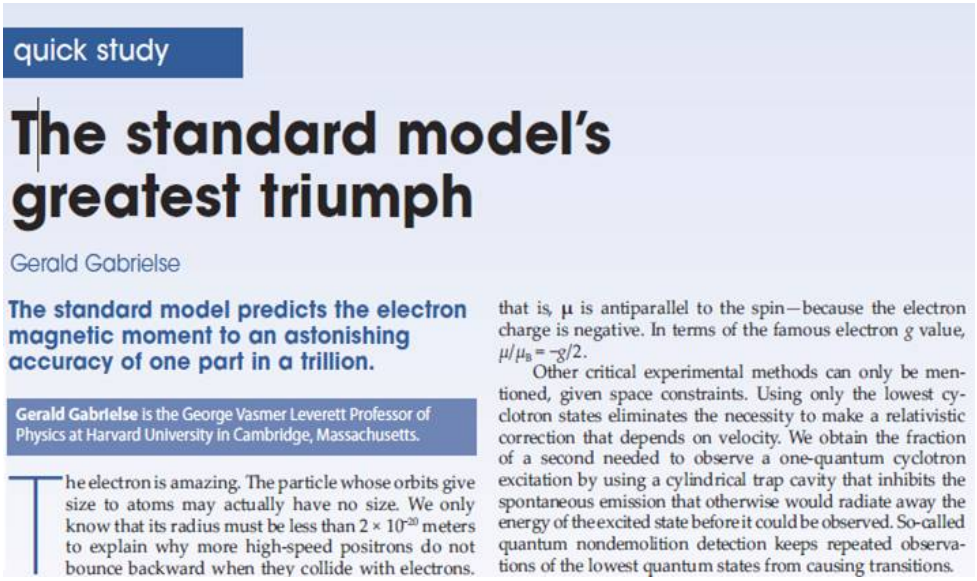
Appendix 4: Physics Today Article, December, 2013

Note that the experimental work described here is extraordinary.

However, there is no definitive physical mechanism provided here (or elsewhere) by which the electron can produce a magnetic moment, angular momentum, or mass. There is the comment that the electron has angular momentum but no size. The article also makes a statement about current loops for the magnetic moment, but it provides no definite algebraic model of these loops. Further, it states that electrons may have no size!

But, what really is amazing is that the calculation of the 1 ppt error in the electron's magnetic moment via the Bohr magneton can be carried out to parts per trillion. In correcting this error, they have a highly accurate value for the magnetic moment, but the physical mechanism for generating the magnetic moment in the first place is totally unknown.

It appears that the standard model views the electron as a stationary 10^{-18} cm particle in the Penning trap, and that it has the "magical" parameters of magnetic moment, angular momentum, and mass.



quick study

The standard model's greatest triumph

Gerald Gabrielse

The standard model predicts the electron magnetic moment to an astonishing accuracy of one part in a trillion.

Gerald Gabrielse is the George Vasmer Leverett Professor of Physics at Harvard University in Cambridge, Massachusetts.

The electron is amazing. The particle whose orbits give size to atoms may actually have no size. We only know that its radius must be less than 2×10^{-20} meters to explain why more high-speed positrons do not bounce backward when they collide with electrons. that is, μ is antiparallel to the spin—because the electron charge is negative. In terms of the famous electron g value, $\mu/\mu_B = -g/2$.

Other critical experimental methods can only be mentioned, given space constraints. Using only the lowest cyclotron states eliminates the necessity to make a relativistic correction that depends on velocity. We obtain the fraction of a second needed to observe a one-quantum cyclotron excitation by using a cylindrical trap cavity that inhibits the spontaneous emission that otherwise would radiate away the energy of the excited state before it could be observed. So-called quantum nondemolition detection keeps repeated observations of the lowest quantum states from causing transitions.

The "spin-½" electron has angular momentum $\mathbf{S} = \frac{1}{2}\hbar\hat{\mathbf{S}}$, as Otto Stern and Walther Gerlach famously demonstrated, even though it has no size and nothing is rotating.

The electron, though, does have the magnetism that we might expect if charge displaced from the electron's center rotates to make current loops. Insofar as the electron has a simple internal structure, that magnetic moment $\boldsymbol{\mu}$ is parallel to its spin: $\boldsymbol{\mu} = \mu\hat{\mathbf{S}}$. To measure μ, a single electron is suspended for months at a time in a strong magnetic field $\mathbf{B}$. A weak electric field (henceforth to be ignored, since it adds no fundamental complication) keeps the electron from leaving the measurement apparatus—the Penning trap shown in panel a of the figure.

The electron orients its magnetic moment with $\mathbf{B}$, much as a magnetized compass needle orients in Earth's magnetic field. A compass needle pointed exactly south will stay in that unstable equilibrium state only until a tiny disturbance flips it to the lower-energy, stable equilibrium state pointed north. Energy is not so easily removed from the single-electron magnet. Left to itself in the Penning trap, it would remain either parallel or antiparallel to $\mathbf{B}$ for years; the two states differ in energy by $\hbar\omega_s = -2\mu B$, where ω_s is the so-called spin frequency. The spin and magnetic moment flip direction only when an appropriate oscillating driving force is applied, with more spin flips taking place as the drive frequency approaches ω_s.

The spin frequency is proportional to B, which must then be measured to extract μ. Fortunately, the cyclotron frequency, $\omega_c = eB/m$ for an electron with charge $-e$ and mass m, is also proportional to B, so it can be used as an internal magnetometer. The electron is kept cold—with a temperature less than 0.1 degree above absolute zero—to keep the cyclotron motion in its quantum ground state. As with spin flips, a measurable one-quantum excitation of the cyclotron motion, which increases the energy by $\hbar\omega_c$, requires an appropriate driving force. Excitations take place more frequently as the drive frequency approaches ω_c.

Eliminating B from $\hbar\omega_s = -2\mu B$ and $\omega_c = eB/m$ gives the magnetic moment as a ratio of the two measurable frequencies, $\mu/\mu_B = -\omega_s/\omega_c$. The Bohr magneton $\mu_B = e\hbar/(2m)$ is the magnetic moment for circular electron motion with angular momentum $\hbar$. The magnetic moment μ is negative—

The resulting electron magnetic moment, $\mu/\mu_B = -1.001\,159\,652\,180\,73\ (28)$, is the most precisely measured property of any elementary particle. The uncertainty, in parentheses for the rightmost two digits, is only 2.8 parts in 10^{13}. For comparison, the muon magnetic moment has been measured only about 1/2500 as precisely.

The standard-model calculation

In 1928 Paul Dirac introduced the famous relativistic wave equation that describes an electron and other spin-½ particles. The Dirac equation prediction, $\mu/\mu_B = -1$, is the first and largest of four standard-model contributions that together may be written $-\mu/\mu_B = 1 + a_{QED} + a_{hadronic} + a_{weak}$.

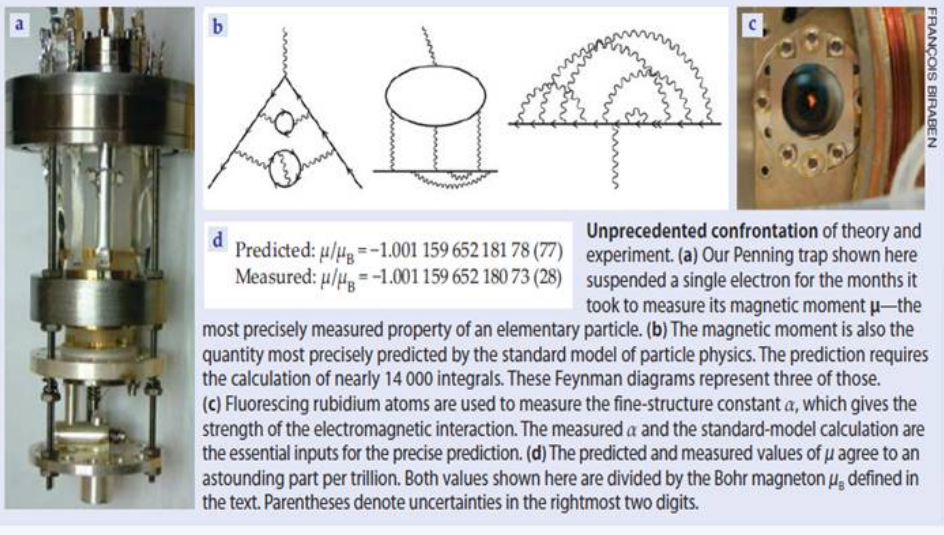
A 0.1% addition to the moment, a_{QED}, comes from quantum electrodynamics (QED), a quantum field theory incorporated into the standard model. QED describes how the electron emits and absorbs photons, some of which interact with the lepton–antilepton pairs of "empty space." The standard model's leptons—the electron, muon, and tauon—are identical point particles except for their differing masses. Each has an oppositely charged antiparticle with the same mass. Because lepton–antilepton pair creation violates energy conservation, the pairs annihilate within the short time allowed by the energy–time uncertainty principle.

A two parts per trillion contribution, $a_{hadronic}$, comes from the electron's interaction with hadron–antihadron pairs. (Hadrons are heavy particles whose internal structure would need to be known here if the correction weren't so small.) The standard-model weak-interaction contribution to the electron moment, a_{weak}, is smaller than the measurement precision.

Quantum electrodynamics gives a_{QED} as a power series in the fine-structure constant, $\alpha = e^2/(4\pi\varepsilon_0\hbar c) \approx 1/137$, which is a measure of the strength of the electromagnetic interaction in the low-energy limit. Specifically,

$$a_{QED}(\alpha) = C_2\left(\frac{\alpha}{\pi}\right) + C_4\left(\frac{\alpha}{\pi}\right)^2 + C_6\left(\frac{\alpha}{\pi}\right)^3 + C_8\left(\frac{\alpha}{\pi}\right)^4 + C_{10}\left(\frac{\alpha}{\pi}\right)^5 + \ldots.$$

Each of the five displayed terms is much smaller than the previous one, but all are needed to achieve the measurement precision of the magnetic moment.



Unprecedented confrontation of theory and experiment. **(a)** Our Penning trap shown here suspended a single electron for the months it took to measure its magnetic moment $\boldsymbol{\mu}$—the most precisely measured property of an elementary particle. **(b)** The magnetic moment is also the quantity most precisely predicted by the standard model of particle physics. The prediction requires the calculation of nearly 14 000 integrals. These Feynman diagrams represent three of those. **(c)** Fluorescing rubidium atoms are used to measure the fine-structure constant α, which gives the strength of the electromagnetic interaction. The measured α and the standard-model calculation are the essential inputs for the precise prediction. **(d)** The predicted and measured values of μ agree to an astounding part per trillion. Both values shown here are divided by the Bohr magneton μ_B defined in the text. Parentheses denote uncertainties in the rightmost two digits.

The C_k are calculated by evaluating Feynman diagrams, each giving a prescription for an integral. The 1, 7, and 72 Feynman diagrams that contribute to C_2, C_4, and C_6 have been evaluated analytically. Julian Schwinger calculated C_2 in 1948. Charles Sommerfield and André Petermann independently determined C_4 in 1957. Stefano Laporta and Ettore Remiddi finished their remarkable evaluation of C_6 in 1996. Toichiro Kinoshita, Makiko Nio, and collaborators numerically evaluated the daunting 891 and 12 672 Feynman diagrams (panel b of the figure gives examples) needed for C_8 and C_{10}—the result for C_{10} was reported only in 2012.

Folding in a fundamental constant

The fine-structure constant is ubiquitous throughout physics. I've already noted its connection to the electromagnetic interaction. In atomic physics, the binding energy, fine-structure splitting, and Lamb shift are all proportional to powers of α. In condensed-matter physics, α characterizes Josephson junction oscillations and quantum Hall resistance steps. In addition, α is an important component of our system of fundamental constants.

The fine-structure constant must be measured, since it is defined with parameters of the standard model that cannot be calculated. Thus a standard-model prediction of μ/μ_B requires an empirically determined α as input. Several measurements together determine α via $\alpha^2 = 4\pi R_\infty h/(mc)$, obtained by substituting the Rydberg constant R_∞ (precisely measured by Theodor Hänsch and collaborators using hydrogen laser spectroscopy) into the definition for α. In 2011 François Biraben precisely determined h/M for rubidium. The Rb mass M had earlier been related to the electron mass m in measurements by Ed Myers and by Wolfgang Quint, Klaus Blaum, and collaborators.

In Biraben's experiment, Rb atoms initially at rest were each given $N = 500$ momentum kicks of $\hbar(k_1 + k_2) \equiv 2\hbar k$ from counterpropagating lasers with precisely measured wavevectors of magnitude k_1 and k_2. The internal energy of each atom remained unchanged insofar as one photon was absorbed while the other stimulated the emission of a photon. (Panel c of the figure shows the fluorescing Rb.) The speed change of the atom, $2N\hbar k/M$, was measured from the Doppler shift of an absorption line to determine h/M. The result, $1/\alpha = 137.035\,999\,049\,(90)$, is consistent with the more precise value that can be obtained from using the measured μ and the standard-model calculation to determine α.

The standard model, with the experimentally determined α as input, predicts an electron magnetic moment, $\mu/\mu_B = -1.001\,159\,652\,181\,78\,(77)$. Owing to the uncertainty in α, the prediction is 2.8 times less precise than the measurement. A comparison of that prediction to the single-electron measurement is the most precise confrontation of any theory and experiment. They agree to 1.1 ± 0.8 parts per trillion—to within 1.3 standard deviations.

A theory of much, but not everything

The standard model is the great success and the great frustration of modern physics. Not only does it predict the electron magnetic moment to a part per trillion, it also successfully incorporates into its patchwork everything measured for the fundamental particles that make up the known matter in the universe, along with what is known about the weak, electromagnetic, and strong forces by which those particles interact. The frustration is that the standard model seems too incomplete to be the final word. It also includes more parameters than physicists would like. Gravity does not fit completely. And the standard model offers no explanation for the dark matter and dark energy that seem to make up most of the universe, nor for how a matter universe could result from the nearly symmetric creation of matter and antimatter in the Big Bang.

Even as we celebrate the great triumph of the standard model, some of us are attempting to use new apparatus and methods to more precisely test the standard-model prediction. Likely we have more to learn from the amazing electron.

I thank François Biraben, Toichiro Kinoshita, Makiko Nio, Elise Novitski, Lee Roberts, and David Wineland for helpful comments.

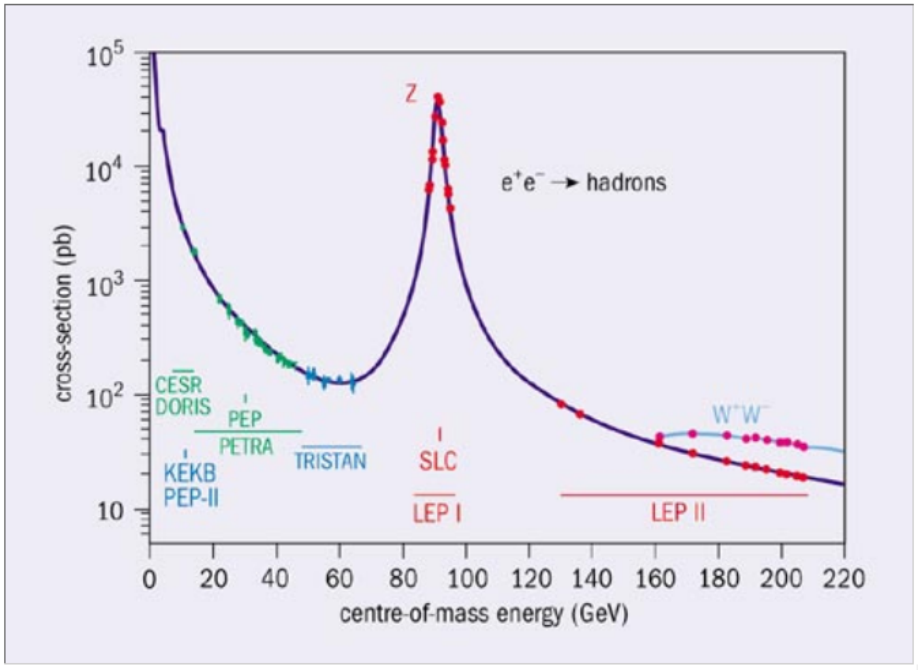
Additional resources

- D. Hanneke, S. Fogwell, G. Gabrielse, "New measurement of the electron magnetic moment and the fine structure constant," *Phys. Rev. Lett.* **100**, 120801 (2008).
- R. Bouchendira et al., "New determination of the fine structure constant and test of quantum electrodynamics," *Phys. Rev. Lett.* **106**, 080801 (2011).
- T. Aoyama et al., "Quantum electrodynamics calculation of lepton anomalous magnetic moments: Numerical approach to the perturbation theory of QED," *Prog. Theor. Exp. Phys.* **01A**, 107 (2012).

==========

Appendix 5: Graphical Cross Section of e+e- Collisions

(Typical unreferenced e+e- graphic, taken from internet for temporary convenience)



==========

Appendix 6. My Helium-3 Transducer/Strain Gauge Appears to Have Made it to the Smithsonian

The version I built is more like the white one on the far left in the picture below. See drawing in Section 17. It is most strange to note, however, that my name seems to have gotten lost somewhere.

A PHYSICS DEPARTMENT PUBLICATION — MARCH 2009

PROTON

PHYSICS REPORT ON THINGS OF NOTE — VOLUME 8 NUMBER 3

The Straty-Adams Pressure Transducer is part of Smithsonian's Fall 2008 Re-Opening

Contributed by Dwight Adams

In 2000, the Comite International des Poids et Measures announced that the ^{3}He melting pressure would be adopted as the basis for the temperature scale from 0.65 K (its previous lower limit) to 0.9 mK. Shortly afterwards, **Professor Dwight Adams** had an email from **Dr. Paul Forman**, Curator in the American Museum of Natural History, inquiring about the possibility of UF donating the original "Straty-Adams" pressure transducer to the Smithsonian.

At the Smithsonian, left to right, Dr. Roger Sherman, Associate Curator, Professor Dwight Adams, Dr. Paul Forman, Curator

Without hesitation, Adams said that if he could find the original transducer he would be glad to donate it to the Smithsonian's collection. This was the quintessential recognition for the transducer to be among the Smithsonian's collection. Adams had suggested ^{3}He melting pressure thermometry based on the ultra sensitive transducer shortly after making the first melting pressure measurements with it in 1967. It had taken 37 years to go from the suggestion to the adoption of the scale.

After the email correspondence with Dr. Forman, and looking through drawers of transducer "junk" that had been tucked away in the lab, Adams found one of the first transducers that Gerald Straty had constructed from the original design. He also located six or eight other transducers of various designs that had been constructed over the years to meet different needs of a particular experiment. Dr. Forman indicated that the Smithsonian would like to have the whole lot of them for its collection, which Adams packaged up and sent to him.

In October, Adams accepted Dr. Forman's invitation to visit the Smithsonian to videotape a description of the pressure transducers. The place was in a state of great disarray since it was undergoing a very thorough makeover intended to allow better display of the artifacts that it has in its collection. The re-opening of the Museum was in November 2008.

Pressure transducers (also called strain gauges)

The American Museum of Natural History web page states, "The Museum has more than 3 million artifacts in its collection. Information and photos of selected objects is available in the online collections database. The database is a work-in-progress and new items will be added regularly. A separate database covers archival collections."

Upcoming Event

The annual Spring Picnic, hosted by the Society of Physics Students, will be on Saturday, April 11th at Lake Wauburg from 12:00pm to 4:00pm. There will be plenty of food (hamburgers, hot dogs & veggie options) and the student vs. faculty softball rivalry will continue!

All faculty, staff, and students are invited to come out and bring their families & friends.

EDITORS
Alan Dorsey, Chair
Pam Marlin

college of liberal arts & sciences

UF UNIVERSITY of FLORIDA
The Foundation for The Gator Nation

Department of Physics, PO Box 118440, University of Florida, Gainesville, Florida 32611
P - 352-392-0521 F- 352-392-0524 physicsnews@phys.ufl.edu http://www.phys.ufl.edu